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Municipal Wastewater Control Technology Research Strategy, 1980-1984

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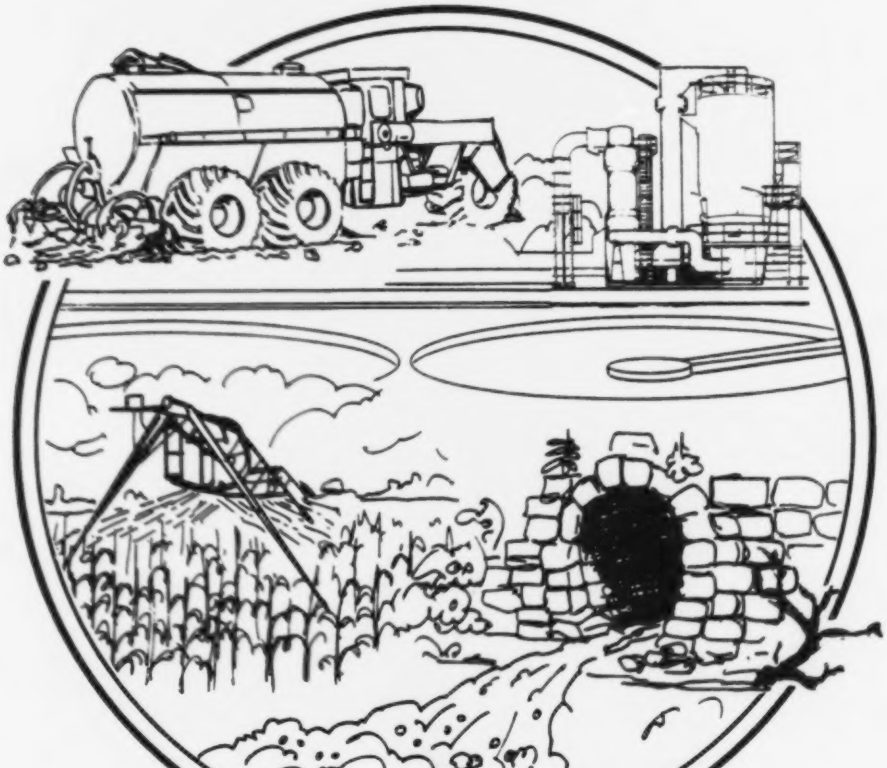
Municipal Wastewater Control Technology

Research Strategy 1980 - 1984

Municipal Wastewater and Spill
Prevention
Research Committee

July, 1980



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16. ABSTRACT The purpose of this document is to identify the requirements for R&D support of program office activities and to summarize as concisely as possible how ORD is responding or intends to respond to the identified requirements. It goes beyond the response to immediate or short-term requirements and provides insight to the direction that longer term research efforts are expected to take. Thus, both the efforts to solve current problems are accounted for and the current perception of research necessary to address anticipated problems or technology needs is identified. The end product, the "strategy," is the result of the efforts of the Research Committee established for this purpose by the Assistant Administrator for Research and Development. As such it represents the concensus view of the Agency as to the shape or form that the R&D relating to municipal wastewater will have over the next several years. It should be noted here that the official name of the Committee is the Municipal Wastewater and Spill Prevention Research Committee. In view of the considerable differences between the municipal wastewater and spills technology and Agency focus the Committee decided to develop two strategies, one for Municipal Wastewater R&D and one for Spills Prevention R&D. This document deals only with the former.

17. KEY WORDS AND DOCUMENT ANALYSIS

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December 1980

MUNICIPAL WASTEWATER CONTROL TECHNOLOGY
RESEARCH STRATEGY 1980 - 1984

PREPARED JOINTLY BY:

Office of Research and Development

and

Office of Water and Waste Management

U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

PREFACE

Beginning in 1977, the Environmental Protection Agency (EPA) undertook a comprehensive review of its research planning and management and reported its findings to the Congress, submitting The Planning and Management of Research and Development in June, 1978. To address some of the problems identified, a pilot project was initiated to examine the feasibility of planning research and development programs by committees representing the Agency's primary organizational elements. This project was the first attempt within EPA at a major joint planning effort between its research, regulatory, and operational components. Research Committees were formed to plan programs in five areas--drinking water, industrial wastewater, pesticides, mobile source air pollution and particulate air pollution. Each committee was co-chaired by the Office of Research and Development (ORD) and the appropriate, corresponding regulatory, organization - the Office of Water and Waste Management; the Office of Air, Noise and Radiation; or the Office of Toxic Substances.

This document describes the research and development strategy developed by the Municipal Wastewater and Spill Prevention Research Committee. In view of the considerable differences in technology between the municipal wastewater area and the spills and uncontrolled hazardous waste sites area, the Committee decided to develop two strategies, one for Municipal Wastewater R&D and one covering Spill and uncontrolled hazardous waste sites R&D. This document deals only with the former. This strategy reflects the current perspectives of EPA's research requirements and research capabilities. The document will serve as the basis for detailed planning in those ORD laboratories implementing research on municipal wastewater pollution control. To be properly responsive to evolving regulatory priorities and emerging scientific findings, however, the strategy will be subject to at least one annual revision, in concert with EPA's planning and budgeting cycle.

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MUNICIPAL WASTEWATER RESEARCH STRATEGY

INTRODUCTION

The municipal wastewater research program is designed to provide the technology and science support to the Agency offices that implement the regulatory aspects of the applicable legislative acts.

While many legislative acts have some relationship to municipal wastewater R&D, the most significant in terms of research authorization and requirements for support from the Office of Research and Development (ORD) are the Federal Water Pollution Control Act (PL 92-500), as amended by the Clean Water Act Amendments of 1977 (PL 95-217), and the Resource Conservation and Recovery Act of 1976 (PL 94-580).

The Agency offices with the primary responsiblity for implementing various portions of the legislative acts are generally referred to within EPA as the "program" offices. This document will utilize that term as a convenient short hand to describe the users, or "clients" for ORD outputs and where possible every attempt has been made to relate ORD activities to the appropriate client office.

The purpose of this document is to identify the requirements for R&D support of program office activities and to summarize as concisely as possible how ORD is responding or intends to respond to the identified requirements. It goes beyond the response to immediate or short-term requirements and provides insight to the direction that longer term research efforts are expected to take. Thus, both the efforts to solve current problems are accounted for and the current perception of research necessary to address anticipated problems or technology needs is identified. The end product, the "strategy," is the result of the efforts of the Research Committee established for this purpose by the Assistant Administrator for Research and Development. As such it represents the concensus view of the Agency as to the shape or form that the R&D relating to municipal wastewater will have over the next several years. It should be noted here that the official name of the Committee is the Municipal Wastewater and Spill Prevention Research Committee. In view of the considerable differences between the municipal wastewater and spills technology and Agency focus the Committee decided to develop two strategies, one for Municipal Wastewater R&D and one for Spills Prevention R&D. This document deals only with the former.

The establishment of the Municipal Wastewater and Spill Prevention Research Committee is an outgrowth of a FY 1978 pilot effort involving five committees. The success of that effort in increasing and improving communication and understanding between the program offices and ORD led to expansion of the activity to a continuing effort involving twelve research areas. They are:

- Water Quality
- Municipal Wastewater and Spill Prevention
- Drinking Water
- Industrial Wastewater
- Solid Waste
- Toxics Testing and Assessment
- Mobile Source
- Oxidants
- Gaseous, Inhalable Particulates
- Hazardous Air Pollutants
- Pesticides
- Non-Ionizing Radiation

The Municipal Wastewater and Spill Prevention Research Committee has working interfaces with the Water Quality, Industrial Wastewater, Drinking Water, and Solid Waste Committees. These interfaces are discussed within the appropriate portions of the strategy.

The program offices were relied upon to identify research requirements and to prioritize the technology or work areas with the R&D program. About 200 requirements were initially listed by the program and regional offices. These requirements were categorized in accordance with the major work areas in the R&D program and the Committee determined their relative priority for R&D outputs. The strategy is primarily a reflection and refinement of this effort.

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EXECUTIVE SUMMARY

This document presents the research strategy adopted by the Municipal Wastewater and Spills Prevention Research Committee in the area of municipal wastewater pollution control. The spills prevention strategy is described in a separate text.

The strategy document is intended to facilitate the Research Committee's exercise of its oversight function by identifying research planned for the 1980 through 1984 timeframe and relating it to the research requirements of headquarters and regional offices. Roughly 185 individual research requirements solicited from five headquarters and ten regional offices are arrayed against the nine technological areas of research as well as the supporting health effects research program.

Office of Research and Development

The identified requirements are then matched against the program of research planned by ORD through 1984 using key outputs identified in the Laboratory Output Plans (LOPs) to determine which requirements are being addressed by the current plan of research and which have been left unaddressed. Where gaps have been identified corrective steps such as the reprogramming of funds have been taken.

In the following sections the major outcomes of the strategy formulation effort and the pertinent recommendations of the Committee are described.

1. THE RESEARCH PLAN RECOGNIZES FIVE AREAS OF HIGHEST PRIORITY RESEARCH

The evaluation of requirements for R&D support to Agency programs in solving high priority technical problems or in meeting major objectives of the Agency resulted in the placing of the following areas in the highest priority for implementation of research and development activity:

- Provision of expert technical support in the implementation of the Agency's Innovative and Alternative (I/A) Technology program and post-construction evaluation of innovative facilities. The high priority placed on this area is reflected in ORD's commitment to a more active program in response to OWPO's request.
- Resolution of health issues and development of the control technology necessary to recommend environmentally acceptable management methods for municipal wastewater sludges.
- Assessment of the types and concentration levels of toxic materials in municipal wastewater, determination of the fate of toxicants in publicly owned treatment works and development of control options and technologies to mitigate the discharge of toxic pollutants to the urban environment.

- Provision of expert technical support and continued development of new or improved on-site wastewater management systems.
- Development and demonstration of technologies aimed at energy recovery and conservation including natural treatment systems, land application, innovative conservation techniques or conventional systems and other approaches.

While these are the highest priority areas, there are many others that require large-scale R&D support. They are identified and the supporting R&D is discussed in the specific technology areas of the strategy.

2. THE RESEARCH PLAN IS LARGELY RESPONSIVE TO THE RESEARCH REQUIREMENTS EXPRESSED BY EPA OFFICES

Based on the match obtained between identified R&D requirements and the current research plan, most research requirements are being met or are projected to be met by the research plan described here. Where potential "gaps" between the plan and the research requirements have been identified, discussions with the cognizant Program Office are being initiated to clarify and detail the requirement and the reprogramming of funds is being undertaken where appropriate.

3. IMPLEMENTATION OF THE BASE RESEARCH PLAN IS SERIOUSLY JEOPARDIZED BY THE ON-GOING INFLATIONARY SPIRAL

The research plan identifies the R&D outputs projected through 1984 assuming a flat budget and does not take into account the decline in purchasing power of R&D dollars, While an exact estimate of the effect of inflation on government R&D expenditures has not been calculated here, the effect can be approximated by use of the deflator used to adjust the GNP total for real growth. Figure 1 shows the impact of inflation since 1977 on what is projected to be a flat municipal wastewater budget from 1981 through 1984. Inflation since 1977 has accounted for over a 40% reduction in the real purchasing power of R&D funds. Even in terms of 1980 dollars the effect is significant: the fiscal year 1982 budget currently being assembled will most likely depreciate by over 20% (8% inflation compounded over 3 years) before a dollar is spent. The size and persistance of this inflationary trend is such that ORD managers are hard pressed to maintain the viability of needed, on-going projects even without responding substantively to new research requirements.

Figure 2 shows the increase in absolute dollars needed to maintain the same level of purchasing power as provided in (deflated) 1981 dollars, again assuming an 8% annual rate of inflation.

ORD managers are currently evaluating available options for coping with the inflation problem ranging from a general retrenching across all research areas to significant cuts in selected lower priority research efforts.

4. EXPANDING RESEARCH REQUIREMENTS REQUIRE AN AUGMENTED R&D BUDGET TO MAINTAIN RESPONSIVENESS AND PRODUCTIVITY

Significant new research requirements have been identified that have important budgetary implications for ORD. In order to accommodate the new demands and maintain the pace and scope of existing research effort, additional funds are required. In the absence of additional funds the new research requirements could be addressed only through the complete curtailment of various major research activities described in this document such as the efforts in Municipal Wastewater Reuse and Water Conservation, Urban Runoff, and Plant Operation and Design. While these three areas are, in the view of the Committee, of a lower priority in the research plan than the other areas, they nevertheless support important Agency commitments whose integrity would be seriously compromised by the abandonment. Furthermore, the funds made available by wholesale reprogramming in these three areas would still be quite insufficient to satisfy the expanded research requirements. The Committee has concluded that while a reduction in research emphasis is appropriate in selected areas, a productive program of research responsive to expanding research requirements is possible only with significant additional funds.

5. SEVERAL NEW INITIATIVES ARE RECOMMENDED TO ADDRESS EXPANDING RESEARCH REQUIREMENTS

As indicated above, the reprogramming of existing funds is not always a viable response to an identified gap in the research plan either because of the magnitude of the resources required or because of competing priorities for the research dollar. In addition requirements for research in new or expanded areas are straining an already tight research budget. For those reasons the Committee recommends that certain significant research requirements be addressed through the adoption of specific new initiatives described here and in the document itself.

Table 1 summarizes the impact of the recommended initiatives upon the base operating budget for the 10 research areas through 1984. Table 2 provides details of the projected budget allocation at the subobjective level and indicates the precise areas to be supported by the new initiatives. Both tables assume a total base budget equal to the base projected for FY 1981. Figures 3 and 4 show the anticipated funding flow for the 10 research areas under the base budget and the base budget plus the new initiatives, respectively.

Priority 1 Initiative: Evaluation of Innovative and Alternative Technologies.

Evaluations of I&A projects authorized under Section 105(j) of CWA are to be carried out starting in 1982. Resources required are as follows:

1982: $2 million and 2 new positions

1983: $4 million and 2 additional positions

1984: $8 million and 2 additional positions.

Priority 2 Initiative: Utilization of Natural Treatment Systems.

This is a new initiative focusing on the development of natural systems for wastewater treatment including land application, the use of wetlands for treatment and aquaculture. Cost of the initiative: $1 million per year starting in 1982; no additional research positions proposed.

Priority 3 Initiative: Evaluation of Beneficial Use and High-Rate Land Application of Sludge.

The first component of this initiative is the development of a methodology for the protection of groundwater from priority pollutants and sludge disposal to the land. High-rate methods such as landfilling will be evaluated in addition to lower rate systems. Cost: $750 K per year and no additional positions.

The second element is a high-visibility sludge land application program. This would provide the resources to sponsor a program actively promoting land application of sludge on farms. It is based on the public acceptance techniques developed by ORD and the Farm Bureau in previous projects with farms in Ohio. Techniques developed earlier for achieving local acceptance of this approach will be tested and evaluated. Cost: $1 million per year and two additional positions.

Priority 4 Initiative: Health Aspects of SWF Systems, Aquaculture, and Urban Runoff.

This initiative responds to several Program Office concerns regarding health effects associated with small wastewater flow systems, aquacultural by-products and the impact of urban runoff on users of reciving waters. The initiative requires $600 K per year starting in 1982 and no new research positions.

Priority 5 Initiative; Wastewater Process Development.

The initiative has four components:

- Development of more cost-effective phosphorus removal technology: $500 K per year starting in 1982 and no additional research positions are required.
- Assessment of the need for ammonia removal and nitrogen management: $250 K per year starting in 1982; no additional research positions needed.
- Creation of research center for small wastewater flows (including transfer of clearinghouse from CERI to MERL): $500 K per year starting in 1982 and no additional positions.
- Development of improved biological systems: $1 million per year starting in 1982 and one additional position.

Priority 6 Initiative: Energy Conservation and Recovery at Municipal Treatment Plants.

The focus here is on the development of methods and techniques for achieving energy savings at POTWs. The cost of the initiative is $750 K per year beginning in 1982; one additional research position is required.

The six proposed new initiatives described are summarized in the table below:

Summary of Initiatives

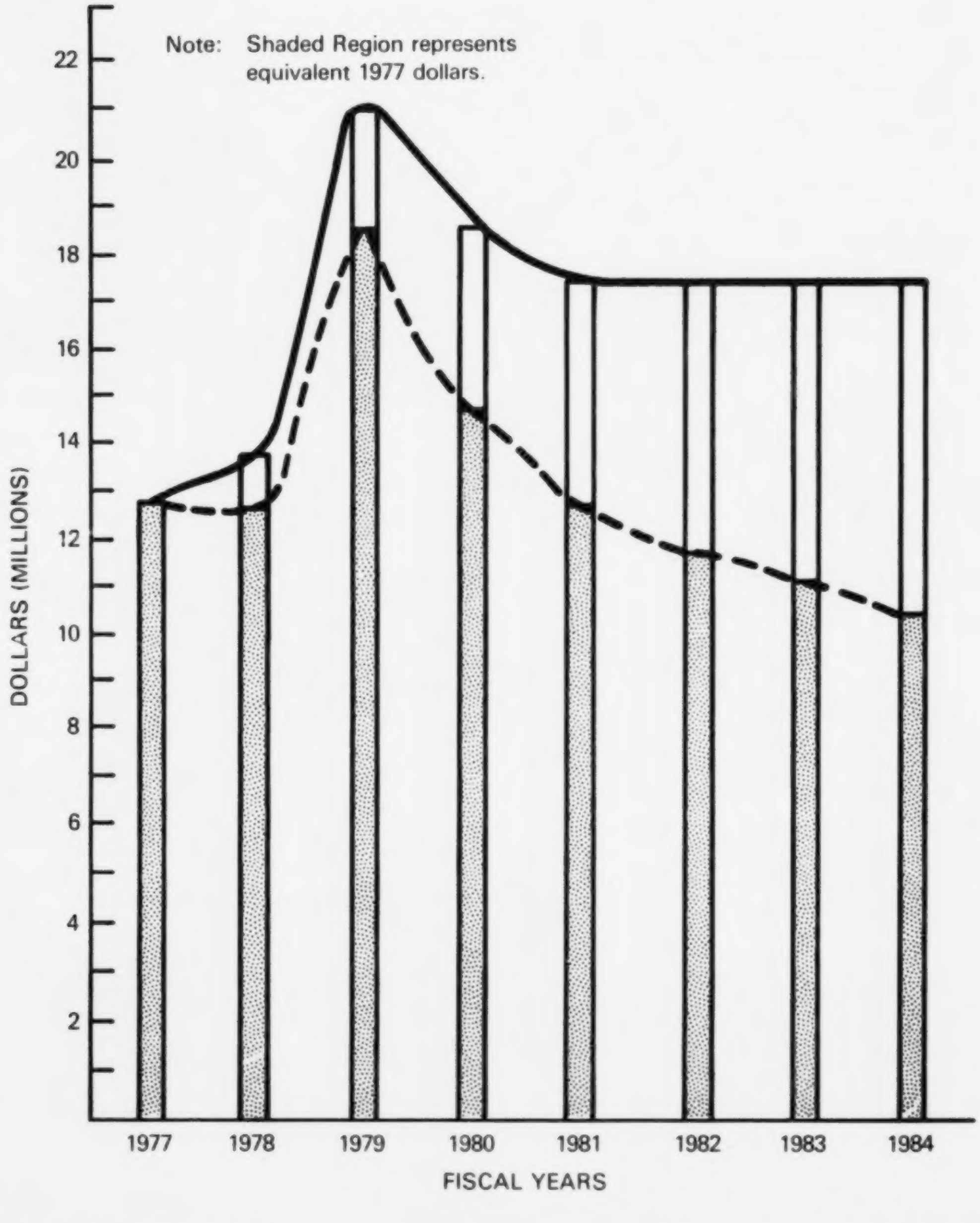
Initiative	Funds Required 1982	1983	1984	New Positions
1. I&A Evaluations	$2 million	$4 million	$8 million	2 per year in 1982 thru 1984
2. Natural Systems	$1 million	$1 million	$1 million	0
3. Promotion of Sludge Application	$1.75 million	$1.75 million	$1.75 million	2
4. Health Effects	$600 K	$600 K	$600 K	0
5. Wastewater Process Development (WPD)				
(a) Phosphorus Control	$500 K	$500 K	$500K	0
(b) Ammonia Assessment	$250 K	$250 K	$250 K	0
(c) SWF Research Center	$500 K	$500 K	$500K	0
(d) Improved Biological Syst.	$1 million	$1 million	$1 million	1
WPD Total	$2,250 K	$2,250 K	$2,250 K	
6. Energy Conservation and Recovery	$750 K	$750 K	$750 K	1
TOTAL	$8,350 K	$10,350 K	$14,350 K	6 in 1982 rising to 10 by 1984.

6. THE RESEARCH PLAN RECOGNIZES THE ROLE OF EXPLORATORY RESEARCH AND PROVIDES PRIORITIES FOR THAT EFFORT

The EPA Science Advisory Board, Congressional Committees and others have for several years strongly recommended that the EPA R&D programs increase the level of effort devoted to exploratory research. ORD has responded to these demands by establishing an ORD policy which requires that 15% of extramural resources be committed to exploratory research. This research is not limited to a single implementation mode but can be accomplished through in-house efforts or by contract, cooperative agreement or research grant.

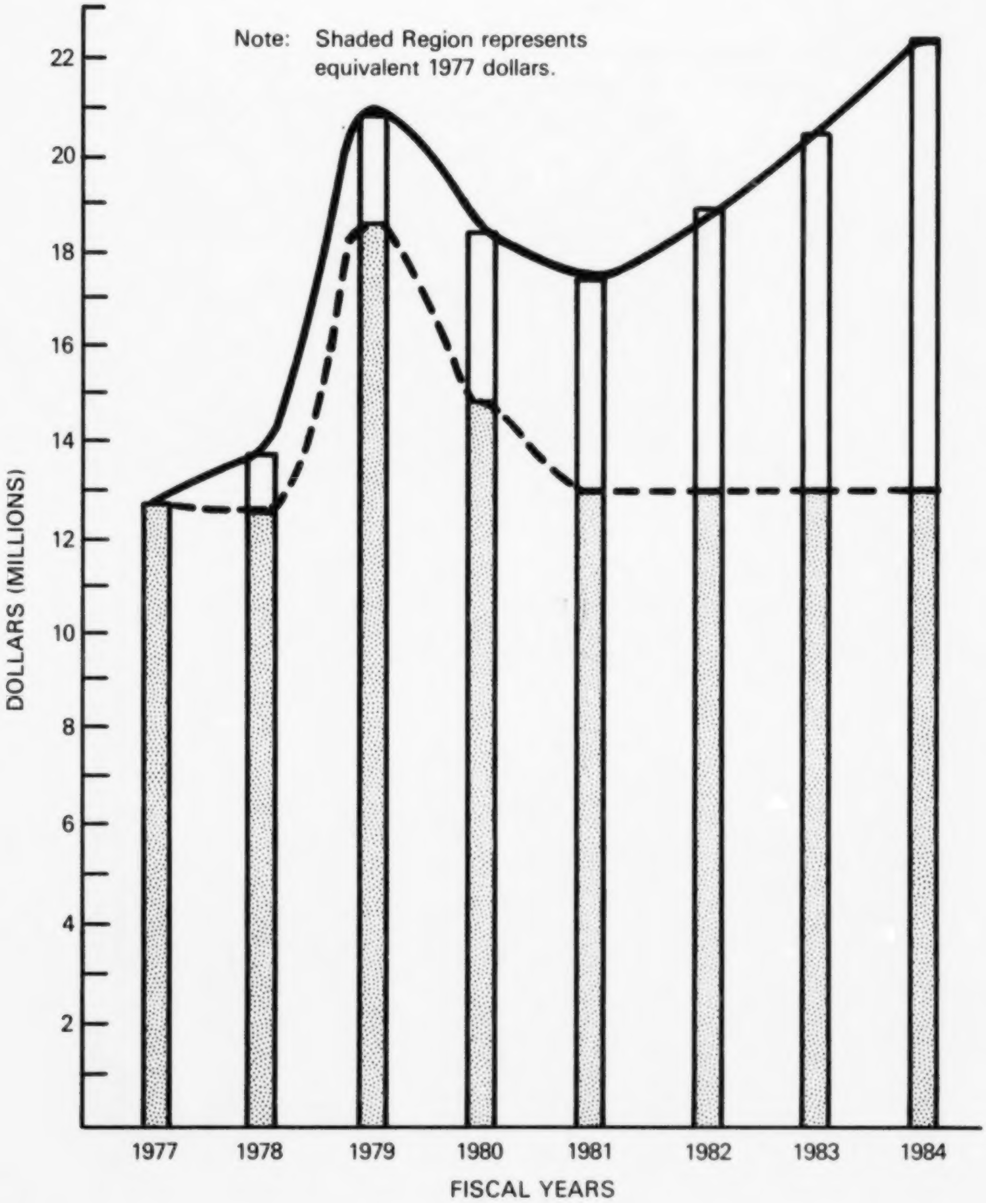
In addition, the Office of Exploratory Research has been established for the purpose of expanding the use of peer-reviewed research grants. A large portion of the 15% of extramural resources will, therefore, be applied to peer-reviewed grants. The resources identified in this strategy document include those which will be utilized for exploratory research. The Committee will delineate the technology areas most compatible with such research efforts.

FIGURE 1. EPA/ORD BUDGET TOTALS FOR MUNICIPAL WASTEWATER POLLUTION CONTROL SHOWING THE EFFECT OF INFLATION ON PURCHASING POWER SINCE 1977



*The equivalent 1977 dollars were calculated using the GNP Implicit Price Deflator published by the Department of Commerce/Bureau of Economic Analysis and assuming an 8% deflator for 1982-1984. The 1978 and 1979 totals do not include $9.5 MM for the Lubbock, Tex. Project and $7 MM for the Denver Reuse Project, respectively.

FIGURE 2. EPA/ORD BUDGET TOTALS FOR MUNICIPAL WASTEWATER POLLUTION CONTROL SHOWING THE ADDITIONAL FUNDS NEEDED TO MAINTAIN PURCHASING POWER DESPITE INFLATION



*The equivalent 1977 dollars were calculated using the GNP Implicit Price Deflator and assuming an 8% deflator for 1982-1984. The 1978 and 1979 totals do not include $9.5 MM for the Lubbock, Tex. Project and $7 MM for the Denver Reuse Project respectively.

TABLE 1. ALLOCATION OF R & D RESOURCES PROJECTED BY FY, 1980-1984 INCLUDING NEW INITIATIVES ($000's)

R & D Resources Allocated
(Total In-House & Extramural $000's)

Research	FY '80	FY '81	FY '82	FY '83	FY '84
Wastewater Process Development	2340	2020	2095 1,680	1585 2,250	1550 2,250
Toxic Pollutants Control	1945	1432	1770	1835	1815
Municipal Sludge Management	3680	3645	3510 1,000	4105 1,750	4217 1,750
Plant Design and Operation	1450	1809	1167 150	1169 750	1185 750
Land Application of Wastewater and Aquaculture	1214	1292	1600 1,000	1360 1,000	1405 1,000
Urban Runoff	1120	1300	1573	1379	1450
Conservation and Reuse	1224	980	831	214	215
Small Wastewater Flows	855	850	1075	940	950
Innovative and Alternative Technology	1005	828	760 2,000	905 4,000	905 8,000
Health Effects	3480	3399	3399 600	4000 600	3800 600
TOTALS	18,313	18,198*	18,423* 6,430	17,492 10,350	17,492 14,350

Base Budget
New Initiative

*Includes OEET WMD of $643 K.

TABLE 2. DETAILED ALLOCATION OF R & D RESOURCES PROJECTED BY FISCAL YEAR, 1980-1984, INCLUDING NEW INITIATIVES ($000's)

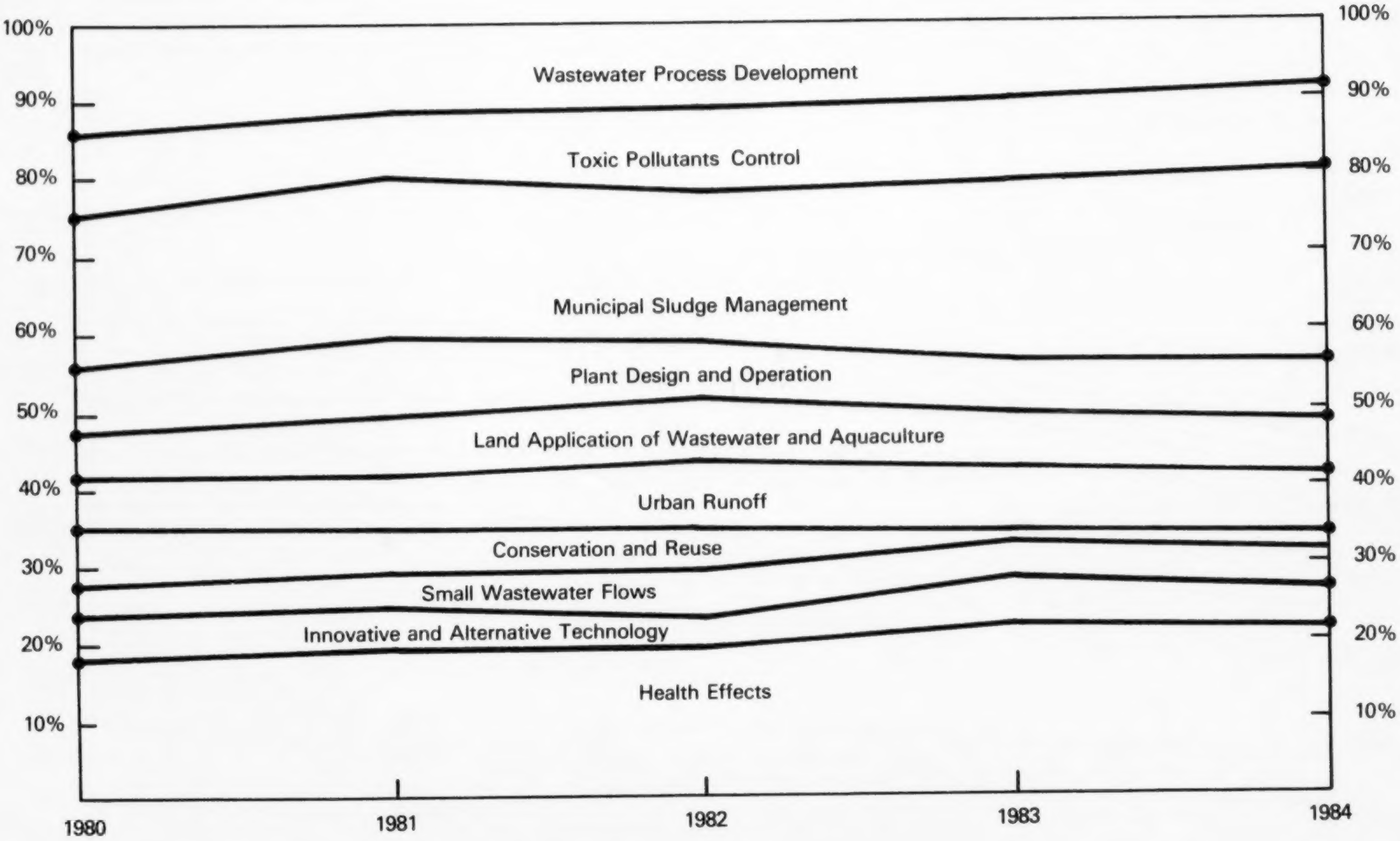
Program Areas	Subobjective	R & D Resources Allocated (Total In-House & Extramural in $000s)					Recommended R & D Initiatives	ORD Contact
		FY '80	FY '81	FY '82	FY '83	FY '84		
Wastewater Process Development	1. New Biological Process Development	850	895	985 / 1000	685 / 1000	710 / 1000	Improved Biological Process Development	Robert Bunch, MERL, Ci (513) 684-7655
	2. Biodegradation and Specific Pollutant Removal	737	500	500 / 680	380 / 1250	320 / 1250	P, NH_3 Control, SWF	
	3. Microbiological Control	753	625	630	520	520		
Toxic Pollutants Control	1. Toxics Data Base: Generation, Management and Indicator Development	380	285	355	315	315		Jesse Cohen, MERL, Ci. (513) 684-7671
	2. Toxics Removal Process Development and Evaluation	955	730	905	1015	1015		
	3. Toxics Treatability	610	417	510	505	485		
Municipal Sludge Management	1. Processing and Stabilization	1060	900	910	905	907		Joseph Farrell, MERL, Ci. (513) 684-7645
	2. Conversion and Energy Recovery	1070	1195	1050	1650	1780		
	3. Land Application Management and Disposal	1550	1550	1550 / 1000	1550 / 1750	1550 / 1750	Priority Pollutant Control and Land Application Promotion	
Plant Design and Operation	1. Analysis of Operational and Design Factors Affecting Performance	710	584	295	304	305		John Smith, MERL Ci. (513) 684-7611
	2. Remedial Methodology Development	740	975	622	865	880		
	3. Energy Use in Wastewater Treatment Facilities	250	250	250 / 150	400 / 750	400 / 750	Energy Recovery and Conservation	
Land Application of Wastewater and Aquaculture	1. Land Application of Wastewater	729	942	725 / 500	560 / 500	555 / 500	Overland Flow	Curtis Harlin, RSKERL (405) 332-8800
	2. Aquaculture	485	350	875 / 500	800 / 500	850 / 500	Aquaculture	
Urban Runoff	1. CSO Control & I/F	580	650	916	1204	1275		Carl Brunner, MERL, Ci. (513) 684-7609
	2. Stormwater and Urban Runoff	540	650	657	175	175		
Conservation and Reuse	1. Conservation and Reuse of Wastewaters	1224	980	831	214	215		John English, MERL, Ci. (513) 684-7613
Small Wastewater Flows	1. Systems Management for Small Communities	265	280	350	415	425		James Kreisl, MERL, Ci. (513) 684-7614
	2. Alternative Technology for Small Systems	590	570	725	525	525		
Innovative and Alternative Technology	1. I & A Technology Evaluation Program Support	755	828	780 / 2000	505 / 4000	505 / 8000	I & A Evaluation	John Smith, MERL, Ci. (513) 684-7611
Health Effects	1. Land Application of Sludge and Treated Wastewater	2200	1999	1899	2200	2600		Herbert Pahren,HERL, Ci. (513) 684-7217
	2. Health Effects Associated with Domestic Water Reuse	600	700	700	700	700		
	3. Appraisal of Health and Other Sludge Treatment, Disposal & Utilization Practices	580	600	600	900	300		
	4. Relationship of Urban Runoff to Health Effects	100	100	200 / 600	200 / 600	200 / 600	SWF, Aquaculture and Urban Runoff	
Totals †	Base Program	18,313	18,198	18,423	17,492	17,492		
	Base Programs Plus New Initiatives	18,313	18,198	24,853	27,842	31,842		

*Additional $500 K/yr provided for research on potable water reuse. Research falls under purview of Drinking Water Research Committee.

†Totals for FY 81 and FY 82 include OEET WMD of $643 K.

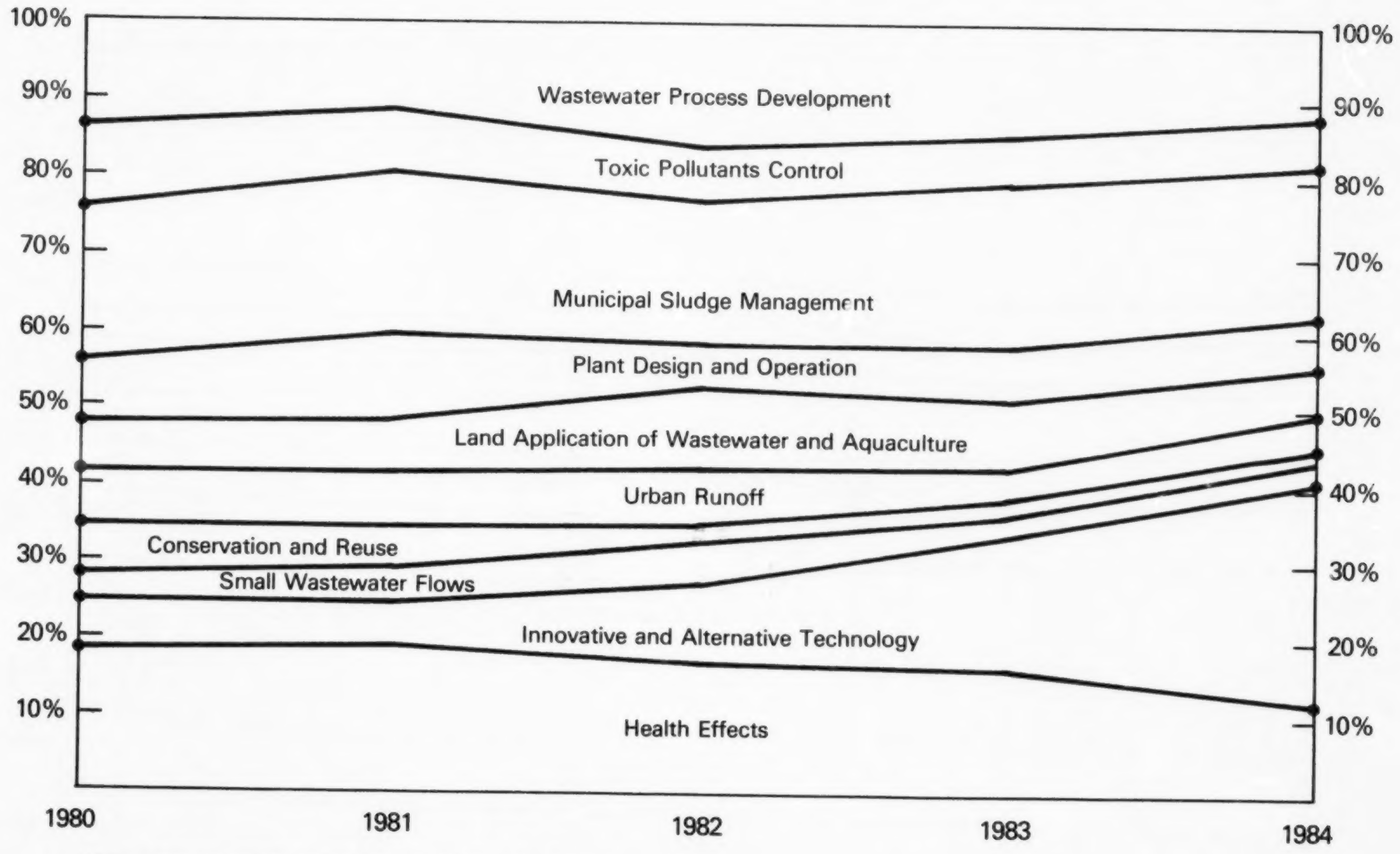
Key:

Base Budget / New Initiative



NOTE: Does not include OEET WMD of $643K for fiscal years 81 and 82.

FIGURE 3. FUNDS ALLOCATED TO INDIVIDUAL MUNICIPAL WASTEWATER RESEARCH AREAS AS A PERCENTAGE OF THE TOTAL BASE BUDGET



NOTE: Does not include OEET WMD of $643K for fiscal years 81 and 82.

FIGURE 4. FUNDS ALLOCATED TO INDIVIDUAL MUNICIPAL WASTEWATER RESEARCH AREAS AS A PERCENTAGE OF THE TOTAL BUDGET INCLUDING PROPOSED NEW INITIATIVES

I. LEGISLATIVE REQUIREMENTS AND AGENCY POLICY

R&D strategy must be responsive to legislative mandates established by the Congress, judicial requirements imposed upon the Agency, and the interpretation of such directives in the form of Agency policy. This section, describes the legislative and judicial basis prompting research in the municipal wastewater control technology area and identifies, where possible, agency policies providing guidance in this area.

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) as amended by the Clean Water Act (CWA) of 1977 (PL 95-217) constitutes the primary force behind research into municipal wastewater control technologies. The following subsections describe the relationship of the legislation to the ten technological and health effects research areas pursued by ORD in municipal wastewater.

WASTEWATER PROCESS DEVELOPMENT

Many goals and requirements of the CWA relating to research and development for cost-effective water pollution control technology development are addressed in this program area, providing agency guidance on the technological capabilities associated with bio-engineering and new biological processes. Traditional areas of activity include the development of alternative disinfection processes, nutrient removal processes, upgrading conventional treatment, physical/chemical unit processes and energy efficient processes.

TOXIC POLLUTANTS CONTROL

Following on the Natural Resources Defense Council (NRDC) consent decree with EPA, the CWA requires urgent attention to the release of toxic metals and organics to the nation's waters. Section 307 of CWA, based on the results of the NRDC Consent Decree, establishes a priority list of 129 toxic pollutants for which effluent limitations must be set for 27 categories of industrial point sources.* Section 307 further allows consideration of credits for the removal of toxics at POTWs in the setting of pretreatment standards for industrial dischargers introducing toxic pollutants into a POTW. Although these legal requirements are intended for the control and abatement of industrial point sources, they prompt a significant amount of research on the control of toxics in municipal wastewaters due to the large number of industrial dischargers to municipal collection systems.

MUNICIPAL SLUDGE MANAGEMENT

By requiring at least secondary treatment of all municipal wastewater flows nationwide by July 1, 1977 (or as late as 1983 where authorized by

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* Table 1 of Committee Print #95-30 of the Committee on Public Works and Transportation of the House of Representatives.

Section 301(i)), the CWA created an immediate need for new or improved technologies for the handling, disposal, and utilization of the massive volumes of sludge produced. The Act requires "the ultimate disposal of sludge in a manner that will not result in environmental hazards" (Section 201). The Act further focuses on the fate of toxics in POTWs, pretreatment of industrial wastes and on the proper utilization and disposal of municipal sludges (Sections 307 and 405).

Additional legislation under the Resource Conservation and Recovery Act of 1977 (RCRA) defines sludges from wastewater treatment plants as solid waste and identifies inadequate and environmentally unsound practices for the disposal or use of solid waste created in the form of sludge and other pollution control residues as a problem in terms of protecting health and the environment. RCRA requires the establishment of a Federal hazardous waste control program, issuance of criteria to define acceptable solid waste disposal practices and a phase-out of unacceptable facilities as "open dumps" in an effort to protect health and the environment while promoting conservation of valuable materials and resources.

PLANT OPERATION AND DESIGN

The ORD plant operation and design program supports the construction grant Step I, II, and III process (O&M manuals, plan of operation, start-up provisions, etc). The program assists EPA Regions and Headquarters with information/assistance in O&M document reviews, O&M inspections, and performance evaluations. Activities include development of technical design and guidance manuals, new management options for more efficient plant operation, met for the detection and correction of plant operating problems and instrumentation and process control applications.

While not the responsiblity of ORD, EPA/state O&M related support activities also involve POTW operator training under Section 104(g)(1) and Section 109(b), NPDES permits issuance/compliance, inspections, and enforcement actions.

LAND APPLICATION OF WASTEWATER AND AQUACULTURE

The Clean Water Act Amendments provided a strong impetus for land treatment in stating that the EPA ". . . Administrator shall not make grants. . . to any state, municipality, or intermunicipal or interstate agency for. . . treatment works unless the grant applicant has satisfactorily demonstrated. . . that innovative and alternative wastewater treatment processes and techniques which provide for the reclaiming and reuse of water, otherwise eliminate the discharge of pollutants, and utilize recyling techniques, land treatment, new or improved methods of waste treatment management for municipal and industrial waste. . .have been fully studied and evaluated. . ." (Section 201(g)(5)). The Act also provides special incentives for the construction of innovative and alternative technologies including land treatment systems. Further, Section 201(d) requires the Agency to encourage the recycling of potential sewage pollutants through techniques that generate agriculture, silviculture, or aquaculture products which can result in revenue-producing facilities.

URBAN RUNOFF

The control of urban stormwater runoff and combined sewer overflows (CSO) is an important element of the overall systems approach to attainment of the goals of the Clean Water Act and its Amendments. Sections 201 and 212 of PL 92-500, for example, placed remedial facilities for control of pollution from combined sewer overflows and urban stormwater runoff on an equal footing with sewage treatment works in the authorization of grants for and definitions of treatment works. Section 211 of the Clean Water Act Amendments, however, disallows any grants through FY 1982 for treatment works specifically for the control of pollutant discharges from separate storm sewer systems. Also, construction grant funding policy emphasizes secondary treatment of dry weather flows prior to combined sewer overflows. Nevertheless, urban stormwater considerations continue to be important to R&D planning since the Section 208 Areawide Waste Management Planning Program retains a high level of emphasis on the implementation of urban stormwater pollution control as an Agency policy. The National Urban Runoff Program (NURP) is initiating a program that will evaluate approaches to the control of urban runoff problems in selected 208 planning areas. These include consideration of both conventional and the 129 priority pollutants.

CONSERVATION AND REUSE

The wastewater reuse program plays a major role in implementing PL 95-217 and PL 92-500 as they encourage and/or mandate the consideration of conservation/reuse/recycle of municipal wastewater. The Agency, as part of the review of national water resource policies, has recently taken a more aggressive stance with regard to water conservation. The implications for additional research due to this increased emphasis will hopefully become more apparent as the Office of Water and Waste Management (OWWM) moves to implement the recommendations of the task force.* Two key elements of the legislation having important research requirements are:

- Multiple use projects are encouraged, although recent Agency policy does not make them totally eligible for construction grants.
- Office of Drinking Water is examining siting problems associated with municipal wastewater discharges above public drinking water intakes and is working toward the development of source criteria for potable reuse of municipal wastewaters.
- Demonstration of potable reuse technology was mandated in the FY 1979 Congressional budget.

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* "Grants and Loans for Municipal Water Supply and Wastewater Treatment Systems" Water Conservation Provisions, "Final Report of Task Force 11, July 30, 1979.

SMALL WASTEWATER FLOWS

Section 104(q)(1) states that "the Administrator shall conduct a comprehensive program of research and investigation. . .into preventing, reducing. . .or otherwise eliminating pollution from sewage in rural and other areas where collection of sewage in conventional, community-wide collection systems is impractical. . .or where soil conditions or other factors preclude the use of septic tank and drainage field systems." In addition, Section 104(q)(3) requires the establishment of a national clearinghouse for receiving and disseminating information concerning this technology area.

Section 201(h) of PL 95-217 authorizes Federal funds for individual (onsite) waste treatment systems provided that the cost is less than that for centralized systems. In addition, Section 201(g) encourages the use of I&A technology applied to the management of small wastewater flows.

INNOVATIVE AND ALTERNATIVE TECHNOLOGY

PL 95-217 also provided for attainment of national water quality goals by increased use of "innovative and alternative" (I&A) technologies emphasizing reuse and recycling of pollutants, improved energy efficiency and lower operating costs. Section 201(g)(5) requires the detailed consideration of I and A technologies as part of the Construction Grant application. The Act authorizes a Federal share of 85% for eligible construction costs for I&A projects and the option to select I&A technologies that are up to 15% more costly than conventional practices. The Act further provides 100% grants to replace or modify I&A technology failures and specific set-asides in the state construction grant allotments devoted to funding I&A projects. Section 105(j) of the Act also authorizes the post-construction evaluation of the performance of I&A projects.

HEALTH EFFECTS

Since many of the provisions of the Clean Water Act are predicated on the need to protect public health, ORD's health effects research supports requirements of the CWAA for the safe treatment, disposal and/or reuse of municipal wastewater and sludge and for the development of a health effects data base for setting water quality standards and effluent guidelines. The health effects research program extends across most ORD wastewater research areas.

RESEARCH COMMITTEE INTERFACES

The legislative mandates and the efforts to develop cohesive Agency policy in the water resources area create the need for interactive planning of research across several research committees. In order to insure that the research effort is both responsive and efficient, water pollution issues involving inter-committee consideration must be identified and the responsiblity for their resolution must be allocated. In various places in the document research efforts requiring the cognizance of other committees are identified so as to facilitate the planning of efficient research. The discussion below identifies those research areas encountered by the Municipal Wastewater R&D Committee which require joint committee review and coordination.

Water Quality Research Committee

1. Urban Runoff (Non-Point Source and Watershed Management)

Research in the area of effects and control of pollution from urban runoff is to be coordinated by the Municipal Wastewater and Spill Prevention (MWSP) Committee and the Water Quality Committee. The tentative delineation of responsibility is that the Water Quality Research Committee for strategy purposes and OEPER for program purposes will have the responsibility for conducting the research required to establish the impacts of urban stormwater and combined sewer overflows on receiving waters. This research will provide the technical backup for establishing wet-weather water quality criteria and will be utilized to assist in determining remedial facility performance requirements for design purposes. The Municipal Wastewater and Spill Prevention Research Committee will be responsible for control technology development of both urban stormwater and combined sewer overflows. Under normal circumstances further development and/or improvement of mathematical models in the urban runoff area will be the primary responsibility of the Office of Environmental Planning and Ecological Research (OEPER) in ORD.

Research required to establish marine water quality requirements related to wastewater discharges will be planned by the Water Quality Research Committee. Technology development for achieving effluent qualities necessary to attain marine water quality requirements will be planned by the Municipal Wastewater and Spill Prevention Research Committee.

2. Clean Lakes Program (Non-Point Source and Watershed Management)

Supportive research for the CLP is to be coordinated through the Water Quality Committee for planning and through OEPER for program activities. A users manual for remedial measures and methods in lake protection and restoration is being prepared under the lead of the Corvallis Environmental Research Laboratory. The Municipal Wastewater and Spill Prevention Research Committee and its associated laboratories (MERL and RSKERL) will plan, develop and evaluate technologies applicable to the Clean Lakes Remedial Program.

3. Wetlands for Wastewater Management

The MWSP and Water Quality Committees have agreed that research relating to the use of wetlands for wastewater treatment (control technology) will be planned by the MWSP Committee. Research dealing with environmental impacts of such systems will be planned by the Water Quality Committee. Implementation of the control technology research is planned by OEET and environmental impacts by OEPER. Control technology addresses the abatement needs for both urban point and non-point source generated wastewater.

Drinking Water Research Committee

Both the Drinking Water Committee and the MWSP Committee have similar and direct interests in the research related to production and feasibility of using renovated municipal wastewater for potable purposes. Both Committees coordinate closely with the Office of Drinking Water, which also has an interest in non-potable reuse. The Committee interface is primarily one of information exchange and, when needed, advice from the other Committee.

Industrial Wastewater Research Committee

1. Toxics

Because of the requirement for industrial pretreatment prior to discharge of effluent to a POTW a strong interactive arrangement is required between this committee and the Industrial Wastewater R&D Committee. The primary focus of the cooperative effort is to be on determining the proper balance of industrial pretreatment of toxics versus pass-through of toxics for treatment at POTWs and the change in beneficial uses of the sludges. Active discussions are on-going between the two committees.

2. Joint Municipal/Industrial Wastewater Management (Treatability)

Coordination with the Industrial Wastewater Research Committee has been established and needs to be further improved. Ideally, one laboratory would have the prime responsibility in this area. A basis for making such a selection is the next objective.

Toxics Testing and Assessment Research Committee

In order to focus on the proper analytical procedures and methods for testing for toxic pollutants, discussion is to be initiated between this committee and the R&D Committee on Toxics Testing and Assessment. A major point will be quality assurance and control methods for technology performance evaluations.

II. THE MUNICIPAL WASTEWATER R&D PROGRAM - PAST AND PRESENT

The current R&D program in municipal wastewater control technology represents both a refinement and an extension of earlier research efforts and, as such, reflects the evolution of the Agency's involvement in wastewater pollution control. This section briefly summarizes the recent budgetary history of the research effort into municipal wastewater pollution control and characterizes on-going research efforts in the nine technological areas and the supporting health effects research.

RECENT BUDGET HISTORY

In fiscal years 1977 and 1978, ORD funded municipal wastewater research in five major areas:

- Waste Treatment Technology
- Runoff Pollution Control
- Environmental Management
- Land Application of Wastewater
- Health Effects

In fiscal 1979, the Environmental Management component was dropped while at the same time a research effort in Urban Toxic Pollutants Control was undertaken. Table II-1 shows the relative funding for the various research areas.

CURRENT RESEARCH PROGRAM

The research activities for 1980 through 1984 have been classified into ten categories, including health effects, as opposed to the five discussed above. On-going research efforts in each of the ten areas are described briefly in the sections that follow.

Wastewater Process Development

Research proceeds in three major areas: innovative biological process development, biodegradation and specific pollutant removal and microbiological control.

In the area of innovative biological process development the research effort focuses on the development of novel processes with the potential for breakthroughs in cost, space requirements, sludge production, efficiency and resource conservation. Currently under evaluation are four engineered systems and two systems involving natural processes:

TABLE II-1

RELATIVE FUNDING OF RESEARCH IN MUNICIPAL WASTEWATER CONTROL TECHNOLOGY, 1977-1979 ($000's)

	Research Area	1977	1978	1979
1.	Waste Treatment Technology	7,794	7,231	(Combined Total)
2.	Runoff Pollution Control	1,043	1,433	9,481.5
3.	Environmental Management	1,379	474	-
4.	Land Application of Wastewater	950	1,122	988.5
5.	Health Effects	1,662	3,391	3,600
6.	Urban Toxic Pollutants Control	-	-	6,849
	TOTAL	12,828	13,651*	20,919*

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* Totals for 1978 and 1979 do not include $9.5 million for the Lubbock, Texas Project and $7 million for the Denver Reuse Project, respectively.

- Engineered Systems
    - Improved efficiency air aeration systems
    - Vertically aligned biological reactors
    - Hybrid biological systems
    - Systems for the control of undesirable organisms
- Natural Processes: isolation to induce the settling out of residual algae.

Research in biodegradation and specific pollutant removal focuses on the management of biological systems aimed at the control of selected pollutants possibly through the use of chemical supplementation to achieve defined effluent residuals. While the control of phosphorus and nitrogen remain an important part of this effort, the major portion of resources is allocated to determining the biodegradation of priority pollutants. Key research results are being incorporated in the treatability manual being prepared for the Office of Enforcement.

Research in microbiological control is evaluating the technical and economic practicability of chlorination, dechlorination as well as a variety of alternative processes for disinfection. These other options include the use of ultraviolet light, chlorine dioxide and ozone for dry weather as well as wet weather and reuse applications.

Toxic Pollutants Control

This area of research aims at characterizing the toxic pollutants in municipal systems and developing control options and technologies to prevent or control the discharge of toxic pollutants into the urban environment.

The program is designed to produce information on the sources of toxic pollutants, on the treatability by conventional and/or new technology and will provide cost analyses to enable selection of the most cost-effective approach. The information will be obtained by surveys of plant influents, effluents and sludges (such as the 25-city survey), by in-house bench and pilot testing, by in-house and extramural studies on the treatability of toxics and by engineering/cost assessments. Documentation will be in the form of reports, technical publications, treatability summaries and ultimately in a guidance manual(s) on control of toxics in the environment.

An analytical methodology for quantifying the priority pollutants in wastewater and sludge has just recently been modified by MERL/EMSL in Cincinnati. The emphasis has been on assessing the magnitude and composition of toxics in wastes received and discharged by POTWs, and conducting urban-wide mass balance (source partitioning) of toxics. This information will be used in the development of a systems analysis approach on the overall impact of source control to toxics by pretreatment versus treatment and/or detoxification at the POTWs. Development of procedures and data on treatability of chemicals in a POTW system will be used to produce a treatability manual in conjunction with a manual establishing pretreatment credits for use by municipalities. This effort is being conducted by the Municipal Environmental Research Laboratory (MERL). A parallel and supportive effort at the Robert S. Kerr Environmental Research Laboratory (RSKERL) is directed at determining the capability of land treatment systems to control toxics.

Municipal Sludge Management

The goal of this program is to develop methods of processing, using and disposing of sludge in the most cost-effective and environmentally satisfactory manner. There are three major areas within this program: processing and stabilization, conversion and energy recovery, and land application management and disposal.

Processing and stabilization includes thickening, stabilizing, disinfecting, and dewatering of sludge. The adequacy of these operations is judged by their ability to reach the desired processing objective, their reliability, cost, and energy requirements. There are a number of projects presently underway within the processing and treatment area. Studies are being conducted to evaluate and compare the performance and cost of thickening and dewatering devices. Reports on the state-of-the-art and costs and benefits of disinfection as well as demonstration of new methods for sludge stabilization that also disinfect are in progress. Evaluation of various novel approaches to anerobic digester operation and power generation from digester gas are being evaluated. Projects are also being conducted to develop processes that will remove or bind toxic metallic or organic pollutants in sludge in an economical fashion.

Conversion processes change sludge to a form which is easier disposed of and which permits its discharge to the land. Furthermore, the volume that requires disposal is reduced significantly. Starved-air combustion is presently being evaluated and utilizes the heat content of sludge alone or with added refuse-derived fuel to complete the conversion process. Coincineration utilizes refuse to upgrade the heat value of sludge. Also in this area, research and development is in progress to characterize the emissions from conventional sludge incineration. Evaluation of European within-vessel composting processes are also being conducted.

In order to achieve reclamation and reuse objectives involving land application of sludge uncertainties concerning the health and ecological effects of some sludge components must be addressed. Current programs aimed at mitigating these uncertainties include:

- Developing a technique which will allow authorities to predict useful lifetime of a site with better correlation to annual loading rate

- Developing a technique which will allow designers to predict the response of plants or crops to a broad range of sludge application rates and practices

- Developing methods which will improve efficiency of nutrient availability and utilization, and conducting fundamental research on how the chemical form of toxicants might be used in the management of inherent risks
- Researching the fate of organic toxicants found in sludge, developing methods of analysis, refining sampling needs, and conducting studies before integrating control procedures with those management schemes to control the impact of pathogens and heavy metals
- Defining the fate of nutrients in the soil, their impact on groundwater, and management practices to preclude environmental degradation of groundwater
- Preparing feasibility studies and procedures based on actual experiences for use of sludges on energy crops
- Assessing the leading "money-crops" and non-food chain uses of organic soil amendments to determine if there are opportunities in that group which do not directly impact the food chain
- Determining the long-term impacts including reversion of land reclamation, landfilling, and other practices of high rate application.

Plant Operation and Design

Broad objectives of the program are to reduce the construction and operational costs of POTWs, improve baseline performance and reliability of performance, reduce energy use, and promote national goals of reuse and recycling.

A variety of activities aimed at understanding the causes of poor plant performance and developing remedial measures is underway. Design-related factors causing poor plant performance are being more clearly defined. Common design deficiencies have been identified and a deficiency checklist is being prepared for use by design and review personnel. Improved design information based on comprehensive cost, engineering analysis, and performance and operational studies of existing POTWs, as well as for emerging treatment processes and techniques is under development. The identification of design deficiencies and the low-cost corrections of them in existing plants, and the prevention of these deficiencies in new designs will result in improved process and system performance and reliability. Insuring the optimum performance of existing treatment facilities and that adequate consideration is given to proper operation and maintenance in the design of new facilities is also being promoted.

Improved reliability of operation is also being sought through the analysis of mechanical reliability of various generic type/application groupings of mechanical components, an exercise which will result in the development of overall plant reliability design information. Given these data, design engineers will be able to design treatment processes for specific levels of reliability and perform cost/reliability analyses for various processes.

Remediation of problems is also being pursued in a variety of ways such as improving the performance of existing biological facilities, including suspended growth and fixed film systems through comprehensive plant evaluations and implementation of Composite Correction Programs will be demonstrated as an enforcement tool for bringing plants into compliance on a statewide basis.

The application of digital computers for plant control will also be explored, not to eliminate the operator, but to provide a tool that can be used to improve efficiency and reduce costs. The potential for use in centralized management of a network of plants to achieve water quality goals will also be studied.

Land Application of Wastewater and Aquaculture

The scope of this program includes the development of new or improved control technology for the effective and economical treatment of municipal wastewater through the use of the soil as a treatment media and the application of aquaculture techniques.

The principal research outputs in the area of land application will be new or improved technology for land-based management of wastewaters and research data for input into comprehensive design manuals. Present projects include: the demonstration and evaluation of a large-scale land treatment system in Lubbock, Texas; a report on nitrogen modifications as they affect the design and operation of rapid infiltration land application systems; assessments of long-term effects of irrigation and rapid infiltration systems; a technical publication on a phosphorus model to design systems in calcareous soils; development of overland flow design criteria for northern climate zones; a technical report detailing high-rate infiltration design and operating procedures for southern parts of the U.S.; publication of field measurement requirements related to determining design loads based on hydraulic limitations; publication on transport through soil of selected trace metals and toxic substances; and evaluation of pretreatment requirements for land application systems including treatment achieved through storage.

In the area of aquaculture, work is being directed to the development of natural systems for the treatment and management of wastewaters. Aquatic organisms under evaluation for their effectiveness as wastewater treatment systems include finfish, bighead and silver carp, freshwater mussels, water hyacinths, and other aquatic species. Natural wetland are also being evaluated for polishing management of municipal treatment plant effluents.

Urban Runoff

Research in this area focuses on the control of both urban stormwater runoff and combined sewer overflows (CSOs). The effort divides into three subobjectives:

- Pollution Problem Assessment
- Stormwater Pollution Control
- CSO Pollution Management.

On-going pollution problem assessment activities include the study of sediment impacts and benthic effects of runoff, a nationwide assessment of receiving water impacts and a matrix approach to documenting the causes and effects of urban runoff and includes the effects of toxic substances. Stormwater pollution control research includes the evaluation of eutrophic lake restoration, a study of the proper utilization of urban wetlands and the compilation of remedial steps involving BEST management practices for abating urban runoff pollution.

Research efforts in CSO pollution management are control systems-oriented with near-term outputs on planning and design principles for urban runoff control facilities, storage/sedimentation facility design and infiltration/inflow control and flow monitoring. Research also includes assessment of the effects of toxic substances on receiving waters.

Municipal Wastewater Reuse and Water Conservation

The major goal of this program is the implementation of research and experimental demonstrations that prove the feasibility and practicability of reusing wastewaters. There are four projects presently underway in this program:

- Identification of significant health constituents in wastewater, their removal within treatment systems, and determination of the proportion of wastewater in receiving waters
- Characterization of the effectiveness of pilot and full-scale wastewater treatment systems for the removal of organics, metals and viruses
- Preparation of documents and guidelines for city planners to assist them in decision making regarding the reuse of wastewater effluents as a means of conserving high quality water through source substitution efforts.
- Evaluation of various strategies for minimizing the effects of drought with particular emphasis given to wastewater reuse alternatives and water conservation and determining the impact of water conservation on municipal sewage systems.

A major component of this effort is EPA's support of potable water reuse at Denver initiated in 1979.

Small Wastewater Flows

The research effort in SWF aims at providing regulatory agencies, planning agencies, consulting engineers and the general public with specific details on the design, operation, applicability, capital and operating costs, and environmental implications of alternatives available for the treatment and disposal of wastewaters generated from individual homes, rural communities, and recreational sources. Research is conducted in two major areas:

- Systems Management for Small Communities
- Alternative Technology for Small Systems

In the first area, on-going projects include: the characterization of existing water quality management districts, the production of interim reports on wastewater treatment, disposal and recycle for problem sources and the generation of data on design, O&M, costs and applicability of options for septage handling, treatment and disposal.

In the second area, alternative technology for small systems, on-going work is focused on developing a baseline report on wastewater generation, building technology, energy systems and other utility systems.

Innovative and Alternative Technology

The I&A Technology research effort is a high-visibility part of the ORD program aimed at diversifying the mix of available treatment technologies capable of selection under the Construction Grants Program. Capitalizing on the impetus of the CWA requirements the research effort is apportioned presently between two subobjectives:

- I&A Program Support
- Energy Use in Wastewater Treatment Facilities

I&A program support activities underway involve the preparation of the annual management effectiveness reports, revision of the I&A Technology Assessment Manual, studies of effectiveness in meeting national goals and the publication of both clearinghouse reports as well as I&A programs and trend reports.

Energy-related activities under I&A comprise research in energy conservation in water reuse and recycle, the development of an energy assessment procedures manual and a report on energy efficiency in wastewater and residuals management.

Health Effects

The health effects research activities of importance to the Municipal Wastewater and Spill Prevention Research Committee support Agency goals in three areas: wastewater and sludge management, reuse and recycling of wastewater, and urban runoff. Research activities in the first area center on attaining an understanding of the health effects associated with innovative technologies for wastewater and sludge management. Studies of aerosols and the potential for groundwater contamination are also progressing. Of particular concern here are the concentrations of microorganisms, organics, pesticides, cadmium, lead, and other metals in municipal sludge and the possible effects of human exposure.

R&D activities in the area of reuse and recycling of wastewater relate to a perceived future requirement to make the most efficient use of water resources and treatment capacity by facilitating potable, industrial and agricultural reuse of treated wastewater. These objectives similarly support the elimination of pollutant discharges and the preparation of guidelines for aquaculture (Section 318 of CWA Amendments).

Research efforts in the urban runoff area aim at relating the degree of treatment of point and non-point source discharges to health effects. Evaluation of the need for advanced wastewater treatment to obtain a virus-free effluent to prevent health effects in recreational waters is a focus as is the development of better indicators of microbiological treatment efficiency.

Monitoring Systems and Quality Assurance

The Monitoring Systems activities support Regions and Program Offices in three areas:

- environmental impact statement preparation
- septic tank problem analysis
- the Enviro-pod program.

These activities involve the ORD responding to requests, primarily from the Regions, for overhead monitoring data. The support is provided as required to meet operational monitoring problems. The resources required for this effort are $323 K per year for FY 1980 through FY 1984.

III. AGENCY RESEARCH REQUIREMENTS

ORD has solicited the research requirements of the various potential user offices, both headquarters and regional, in order to insure a high degree of responsiveness and efficiency in its research efforts. This section summarizes the research requirements identified by five headquarters program offices and the ten regional offices in a series of matrices with the requirements ranked according to their perceived priority. Note that the individual requirements are numbered sequentially within any major research area to enable tracking in subsequent sections.

The five headquarters users of ORD research in municipal control technology are:

- Office of Water Program Operations (OWPO)
- Office of Water Planning and Standards (OWPS)
- Office of Solid Waste (OSW)
- Office of Water Enforcement (OWE)
- Office of Pesticides and Toxic Substances (OPTS).

Research requirements were characterized as being of either high, medium or low priority. While no precise or consistent rule was provided to set priorities, the following may be considered a rough definition of each request category:

- High priority: Research requirement is generally in direct support of prospective Agency policy or regulation or legal mandate. Often the regulatory action has an explicit near-term deadline. The need for and approach to research in the area is clearly understood.
- Medium priority: Research requirement is of indirect or less immediate support of a prospective Agency policy or regulation or legal mandate. Often the regulatory action has only a general time-frame. The need for research is still clear but there is a lesser sense of urgency.
- Low priority: Research requirement is in general support of a developing area of regulation having a possibly indeterminate time-frame. A need for research in the area is perceived but the goals may lack definition or specificity.

Appendix B: Municipal Wastewater R&D Requirements by Technological Area provides a complete, and in many cases expanded, description of the research requirements abstracted in the matrices in this section.

The research requirements of the Agency are discussed in the sections below.

HEADQUARTERS PROGRAM OFFICE RESEARCH REQUIREMENTS

Tables III-1 through III-9 list the R&D requirements of the five headquarters program offices according to either high, medium or low priority.

Across the nine technological research areas the greatest number of requests were in the areas of toxics control, municipal sludge management, soil treatment of wastewater and wastewater aquaculture and urban runoff. A relatively small number of requirements were identified by headquarters offices in the areas of plant operation and design, wastewater process development, conservation and reuse, small wastewater flows and innovative and alternative technology.

REGIONAL OFFICE RESEARCH REQUIREMENTS

Table III-10 identifies Regional Office R&D requirements. The number and specificity of regional requests varies widely and generally reflects the degree of participation of the particular regional office in strategy formulation. For example, Regions, I, II, and V who actively participated in committee activities appear to have compiled explicit and complete characterizations of the research requirements of their regions. Regions IV and VIII responded to solicitations of their requirements through another regional office and have supplemented and detailed their previously identified needs. On the other hand, the requirements attributed to Regions III, VI, VII, IX, and X derive from the statement of research needs of about a year ago and can only be assumed to be representative in the absence of any more recent information to the contrary from those regions during strategy formulation.

No one technological area dominated the Regional office requests; rather the stated needs were spread across the nine technological research areas.

HEALTH EFFECTS RESEARCH REQUIREMENTS

Table III-11 details the priority research requirements of both headquarters and regional offices. Although extending across five of the nine technological areas, health research requests were concentrated in the areas of municipal sludge management and land application of wastewater/aquaculture.

There are a number of other research needs which have not been specifically identified by a Program Office, but which are nevertheless required before making a health assessment or providing input to the regulatory process. These generally apply to several Program Offices and are not listed here explicitly.

TABLE III-1. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PROGRAM OPERATIONS (OWPO)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
HIGH	Energy reduction techniques for hi-energy phases of treatment 1	Identification & quantification of of priority pollutant sources 1	Upgrading/design info to boost performance & reliability 1	Design info for new & high priority existing processes 1	Update land treatment design manual 1	Improve sewer treatment design manual 1		Assessment of existing & new technologies 1	Technology Support Group for Const. Grants Program 1
		Design criteria & op'ing procedures to protect groundwater 2	Design info on digestion w/ enhanced gas production 2	Tech. assistance in developing policy, guidelines, etc. 2	Efficacy of pre-application treatment by lagoons, ponds, etc. 2	Support NEEDS survey requirements 2		Manual of practice on septage 2	Provide addn'l effort for Administrator's I/A initiative 2
			Improved processes for energy recovery from incineration 3		Extend overland flow design criteria 3			Design & operating procedures to protect groundwater 3	
					Design criteria & op'ing procedures to protect groundwater 4				
					Design/operating data for natural systems to meet different effluent qualities 5				

TABLE III-2. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PROGRAM OPERATIONS (OWPO)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTEWATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
MEDIUM	Reduce energy in nontreatment components 2	Treatability studies on existing in-plant processes 3	Evaluation of full-scale conversion systems 4		Site evaluation criteria for rapid infiltration 6	Provide technical assistance team for sewer rehabilitation 3	Develop non-potable reuse criteria for POTW sources 1	Improve design, performance & reliability of technologies 4	Monitor I&A Program for research opportunities 3
	Alternative disinfectants (costs, energy, effectiveness) 3	Improved fixing of toxics in sludge 4	Economic study of co-disposal methodologies 5		Evaluation of design & operational energy considerations 7			Technology Transfer Function 5	Detailed evaluation of selected projects (§105j) 4
		Transport/retention studies for selected toxics 5	Air emission control equipment 6					Evaluate cost-effectiveness (cost & water conservation) 6	
		Screening study of toxics in individual home treatment systems 6	Characterize existing sludge & septage disposal systems 7						
			Transfer available information on dewatering techniques 8						
			BMPs for contaminated sludges 9						

TABLE III-3. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PROGRAM OPERATIONS (OWPO)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTEWATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
LOW		Practical, low-cost technology for toxics 7	Development & transfer of composting technologies 10		Investigate long-term effects of application 8	Develop CS technology for wet/dry weather 4	Determine feasibility of potable reuse 2	Identify needs of the home of 2001 7	
		Technology Transfer function 8	Evaluate ash disposal & extraction for incineration 11		Mgmt. requirements for range of slow-rate irrigations systems 9		Identify important conservation elements & pricing approaches 3		
			Fate & effect of toxics in sludges recycled to agri. lands 12		Evaluate costs of of aquaculture systems 10		Develop analytical protocols for reuse 4		
			Feasibility of metals extraction 13		Evaluate ecological impacts 11		Evaluate energy savings of conservation 5		

TABLE III-4. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PLANNING AND STANDARDS (OWPS)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
HIGH	New processes for toxics removal 4	Pretreatment credits for municipal systems 9	Effect of pre-treatment on sludge quality 14	Toxics formation in POTWs due to design processes, e.g., super chlorination 3	Determine groundwater impacts of toxics 12	BMP selection & evaluation methodology 5			Performance on toxics (concentration & effects) 5
		Protocols for sampling & testing 10	Development of sludge criteria for metals and organics 15			Multiple use projects 6			
		Test indicators & measurement methods 11				Study of toxicants in urban runoff – effect on biol. integrity of stream 7			
		Determine source of priority pollutants 12				Assistance in preparing guidelines 8			
		Treatability studies & influent determination 3				Data for wet weather flow criteria and standards -- impact on POTWs 9			
		Effects of POTW discharge on aquatic life 13				Coop. effort to quantify pollutant sources & impacts 10			
		Perform toxics materials balance on POTWs - incl. air transfer 14							

TABLE III-5. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PLANNING AND STANDARDS (OWPS)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTEWATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
MEDIUM		BAT impact on receiving stream 15				Evaluate BMPs 11			
		Evaluate BMPs 16				Effectiveness of runoff controls 12			
		Identify sources of non-priority pollutants 17				Provide technical support for control programs 13			
		Compare 2^o treatment with source control 18				Trehnology Transfer function 14			
		Fate in re-receiving waters from POTW 19				Economic impact of BMPs 15			
						Effect of runoff on water quality 16			

TABLE III-6. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER PLANNING AND STANDARDS (OWPS)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
LOW		Quantify non-point sources identify effects & controls 20				Develop material balance for urban runoff 17			
		Analyze institutional impediments to pretreatment 21				Areawide evaluation of urban complex for problems & solutions 18			
		Compare point vs. nonpoint source impacts 22							
		Inhibition studies of toxics on POTWs 23							

TABLE III-7. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF SOLID WASTE (OSW)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
HIGH			Assess lead in sludge (forms, availability) 16			Coop. effort to quantify pollutant sources & impacts 10			
			Health risks of different levels of cadmium applied to land 17						
			PCB persistence, adherence to crops, uptake and retention 18						
			Risk assessment of other heavy metals and organics 19						
			Effectiveness of pathogen reduction processes 20						
MEDIUM			Cadmium uptake by crops (tobacco, peanuts, soybeans) 21						
			Nonfood chain application - energy products, reclamation, etc. 22						

TABLE III-8. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF WATER ENFORCEMENT (OWE)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
HIGH		Assessment criteria for BMPs 24				Assessment criteria for BMPs 5			
						Coop. effort to quantity pollutant sources & impacts 10			
						Data analysis & tools for wet weather problems 19			
MEDIUM	General: a. Provide technical support on demand in instrumentation b. Develop improved flow measurement methods								
	General: a. Develop remote sensing methodologies (discharges, collection systems, impacts, etc.)								

TABLE III-9. PRIORITY R&D REQUIREMENTS IDENTIFIED BY THE OFFICE OF PESTICIDES AND TOXIC SUBSTANCES (OPTS)

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
HIGH		Identification/ quantification of sources 1	Assessment of of toxic pollutants in sludge 14			Study of toxicants in urban runoff 7		Screening study of toxicants in home treatment systems 7a	
		Improved protocols for toxics in wastewater 10	Characterization of existing sludge & septage disposal systems 7						
MEDIUM		Treatability studies and influent determination 3	Air emission controls 6			Mass balances for urban runoff 17			
		Mass balances for toxics in POTWs 14							
		Quantification of non-point sources to POTWs 20							

TABLE III-10. PRIORITY R&D REQUIREMENTS IDENTIFIED BY REGIONAL OFFICES

R&D AREA PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION I HIGH	Field investigation of "phostrip" installations 5	Information on POTW and on-site non-industrial toxics 25	Environmentally acceptable land spreading & land filling methods 23	Methods to reduce energy consumption at POTWs 4	Fate of nitrates sodium & heavy metals 13	Demo sewer flushing on large sewers 20	Impact of conservation on POTW & sewer design & op'n 3	Septage treatment & disposal technology (BPT) 8	Procedures for post-const. verification of energy savings 6
	High-energy electron irradiation of wastewater 6		Further info on by product formation by Purifax process 24	Methods to improve operational efficiency 5	Lateral/vertical transport of pollutants 14	Demo microscreening with hi-rate disinfection 21		Methods to predict life of leaching fields 9	Criteria for justification of 100% replacement 7
			High-energy electron irradiation of sludge 25	Methods to identify design deficiencies 1	Detemine safe distances from water supplies 15	Innovative ways to optimize size & operation of CSO facility 22		Septage treatment technologies for for suburban New England 10	Support of I&A Clearinghouse 8
			Assist U. Conn. study of sludge application to corn crops 26		Methods of sampling at aquifer interface 16			Control of acid lime sidestream from septage pretreatment 11	
					Design criteria cost of evapotranspiration systems 17				
MEDIUM			Develop energy sources from sludge (methane recapture) 27		Study nutrient retention in fast percolation lake soils 18	Technical support on 201 projects (CSD) 13			

TABLE III-10. (con't). PRIORITY R&D REQUIREMENTS IDENTIFIED BY REGIONAL OFFICES

PRIORITY \ R&D AREA	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION II HIGH			Evaluate new European technology 28			Feasibility of co-disposal 23		Info on treatment & disposal of septage 2	
			Acceptability of landspreading and thermal destruction of urban area sludges 28a						
MEDIUM					Effect of waste water injection on groundwater quality 19	Short & long-term impact of runoff 24			
LOW							Minimize impact on biota of reuse for cooling 6		

TABLE III-10. (con't). PRIORITY R&D REQUIREMENTS IDENTIFIED BY REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTEWATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION III HIGH				Cost factors for treatment alternatives 6					
REGION IV HIGH	Methods to correct nitrate accumul. in ground waters 7			Refresher courses for operators 7		Data collection for storm events 25			
MEDIUM				More specific POTW design criteria 1				Effects on wetland water quality 12	
REGION V HIGH	Comparison of chlorine & alternative disinfectants 8	Predictive model for chemicals in effluents & sludges 26	Monitoring of Cd in sludge-amended soils 29		Design data for overland flow in northern climates 20	Assessment for wet weather flow criteria 9		Cost/effectiveness and benefits of BMP's 13	Cost performance & reliability data for I&A 4
MEDIUM	Need for disinfection for given effluent 9			Reliability of sand, multi-media & other final filters 8				Determine efficacy of dual septic tanks in series 14	
	By-product contamination by new disinfection methods 10								

TABLE III-10. (cont'd). PRIORITY R&D REQUIREMENTS IDENTIFIED BY REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION VI HIGH			Envir. acceptable sludge mgmt. & disposal options 23						
MEDIUM								Effects on wetland productivity; other options 15	
REGION VII HIGH	Evaluate bio-disc & ABF processes 11					Data on urban storm events 25			
REGION VIII HIGH	Design criteria for safe chlorination 12		Land application practices for for Western U.S. 30	Design parameters for optimum clarifier performance 9	Safe application practices for Western U.S. 21				Demo of vertical tube reactor system 9
	Project decay/persistance rate for Cl_2 in streams 13		Pretreatment & disinfect. guides for land application 31	Improved supernatant quality in anaerobic digestion 10	Pretreatment & disinfection guidance for land application 22				Demo. of wet oxidation of sludges 10
				Reliability of NH_3-N reduction in cold climes 11					Eval. of potential for energy use reduction & recovery 6

TABLE III-10.(Cont'd). PRIORITY R&D REQUIREMENTS IDENTIFIED BY REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION IX HIGH							Assessment of implementation measures 7	Data on small scale treatment technology 1	
MEDIUM			Evaluate systems tradeoffs 32						
LOW							Use of salt water for toilets & groundwater protection 8		
REGION X HIGH	Effect of chlorine on biota 13								
	Develop alternatives to chlorination 8								
	Effect of chlorination by products on biota 10								

TABLE III-11. HEALTH EFFECTS - PRIORITY R&D REQUIREMENTS IDENTIFIED BY HEADQUARTERS AND REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
OWPO HIGH			State of the art health assessment SM-1		State of the art health assessment LA-1				
MEDIUM								Impact of SWF Systems SF-1	
OWPS	No health effects needs identified by program office								
OSW HIGH			Health risk of lead to small children and pregnant women SM-2						
			Assessment of PCBs in dairy products, beef fat SM-3						
			Assessment of effects of other metals and organics SM-4						

TABLE III-11. (Cont'd). HEALTH EFFECTS - PRIORITY R&D REQUIREMENTS IDENTIFIED BY HEADQUARTERS AND REGIONAL OFFICES

PRIORITY \ R&D AREA	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
OWE	No health effects needs identified by program office								
OPTS	No health effects needs identified by program office								
REGION I			Develop acceptable landfilling/ landspreading methods SM-5		Health effects assessment LA-2				
REGION II			Same as above plus: evaluate new European technology SM-6						
REGION III	No health effects needs identified by regional office								

TABLE III-11. (Cont'd). HEALTH EFFECTS - PRIORITY R&D REQUIREMENTS IDENTIFIED BY HEADQUARTERS AND REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTE-WATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION IV HIGH			Impact of land application on groundwater SM-7		Impact of land application on groundwater LA-3				
					Effect of pathogens in soils & aerosols from spray irrigation LA-4				
REGION V HIGH					Dose/response data from aerosols LA-5				
					Need for disinfection prior to application LA-6				
					Fate of pathogens in aquaculture/ wetlands systems LA-7				

TABLE III-11.(Cont'd). HEALTH EFFECTS - PRIORITY R&D REQUIREMENTS IDENTIFIED BY HEADQUARTERS AND REGIONAL OFFICES

R&D AREA / PRIORITY	WASTEWATER PROCESS DEVELOPMENT	TOXIC POLLUTANTS CONTROL	MUNICIPAL SLUDGE MANAGEMENT	PLANT OPERATION AND DESIGN	LAND APPLICATION OF WASTEWATER & AQUACULTURE	URBAN RUNOFF	CONSERVATION AND REUSE	SMALL WASTEWATER FLOWS	INNOVATIVE AND ALTERNATIVE TECHNOLOGY
REGION VI HIGH					Information on viral contamination and carcinogenicity LA-8				
					Procedures/methods for virus identification LA-9				
MEDIUM					Info. on transport of viruses by spray irrigation LA-10				
REGION VII			Fate of viruses and pathogens in land application SM-8						
REGION VIII		Effects of re-used water for irrigation and land application TC-1					Water reuse and conservation techniques CR-1		
REGION IX HIGH			Safety of foodstuffs grown under land application SM-9		Safety of foodstuffs grown under land application LA-11		Effects of percolation into potable groundwater aquifer CR-2		
MEDIUM								Evaluation of various SWF systems SF-2	
REGION X	No health effects needs identified by regional office								

IV. RESEARCH PLAN

This section presents the plan of research for the period 1980 through 1984 broken out by the nine technological research areas and the supporting health effects research. The objective of this section is to relate the R&D requirements presented earlier in Section III to the planned program of research in order to identify where within ORD individual requirements are being addressed and to point out any mismatches or "gaps" between stated requirements and the research plan. This is accomplished for each of the 10 major research areas through the use of "time-line" charts showing the time frame within which various key research outputs are to be generated and the R&D requirements addressed by those outputs. Unaddressed requirements, i.e., those listed in the charts in Section III but not appearing on the "time-line" charts are then discussed for each of the 10 research areas as possible gaps in the research plan. In each case an attempt is made to identify ORD's plans to remedy any identified short-comings. The research outputs listed in the time-line charts are grouped into 3 categories reflecting the nature of the research effort in each area. The 3 categories are being employed within the Office of Environmental Engineering and Technology to assist in the management of research and are defined as follows:

- Category 1: Includes all projects directed toward satisfying an immediate information requirement identified by one or more of the Program Offices. Category 1 projects generally have been requested by Program Offices and completion is sought in a specific time-frame in order to support some regulatory action such as the issuance of a standard.

- Category 2: These projects also provide direct support to a Program Office; however, the need for the information is less immediate and specific.

- Category 3: Projects in the third category provide general support to the mission of the regulatory Program Offices but have not been requested by the Program Office to fill a particular regulatory need. They may be regarded as longer term projects initiated by ORD that advance the data base or the state-of-the-art.

Appendix C provides a listing of outputs by research category for each of the 10 research areas.

The discussion of the 10 research areas continues in the following sections in the order shown here:

- Wastewater Process Development

- Toxic Pollutants Control

- Municipal Sludge Management

- Plant Operation and Design
- Land Application of Wastewater and Aquaculture
- Urban Runoff
- Conservation and Reuse
- Small Wastewater Flows
- Innovative and Alternative (I/A) Technology
- Health Effects Research.

Time-line charts presented in each of the ten sections summarize ORD research efforts by showing the time-frame within which specific outputs relating to each of the stated major objectives are to be accomplished. Outputs identified on the left-hand side of the tables are keyed to the Laboratory Output Plans (LOPs) developed by ORD and additional details on any given output can be obtained by reference to the LOP. The center of each chart shows the approximate time-frame within which specific research elements are to be accomplished through fiscal year 1984. The right-hand column of each table relates the R&D subobjective outputs to the research requirements identified earlier in Section III. This accomplishes two purposes: first, it indicates where within the ORD research effort a particular research requirement is being addressed and, second, it allows as yet unaddressed requirements to be identified for possible corrective action. Also listed for each subobjective area are the R&D resources (in $000s) projected to be allocated to that area through fiscal year 1984.

1. WASTEWATER PROCESS DEVELOPMENT

This program addresses many goals and requirements of the CWA of 1977 (PL 95-217) relating to research and development for cost-effective water pollution control technology. This program directly supports the research requirements of the Office of Water Program Operations in assisting the Construction Grant and regulatory programs in their effort to carry out secondary treatment or higher water quality requirements for publicly owned treatment facilities. The Section 208 water quality planning program is also a major client for this research. In-house expertise is utilized to guide process development, operate pilot plants and conduct technology demonstrations through intramural and external projects. The focus is to seek cost reduction, improved reliability, energy and resource conservation and recovery, and environmental benefits as major outputs. The work also supports the development of processes for recycle and reclamation efforts.

Agency Research Requirements, Priorities and Future Directions

The trend in research for upgrading of POTW design is toward reduction in energy requirements and unit process structural volume, both of which lead to reduced operating and capital expenditures. Rapid technology transfer to the design community is necessary to promote implementation. A wide spectrum of treatment processes is included, ranging from stabilization ponds to innovative biological processes.

A related requirement is for information pertinent to the induced toxicity resulting from chlorination of wastewater, and the feasibility of using alternate disinfection methods such as ozone and ultraviolet light.

Overview of Objectives

The major objective of this portion of the research effort is the development of improved treatment and control technology in the following areas of concern:

- New or improved biological process development
- Biodegradation and specific pollutant removal
- Microbiological control.

ORD Plans and Activities

Tables IV-1a through c summarize planned research in wastewater process development through 1984. The three tables characterize the research plan as currently envisioned assuming no cutbacks in the resources shown at the base of each chart. The Research Committee has determined, however, that the indicated resources are insufficient to allow ORD to carry out additional research deemed important by the Committee in several areas. Accordingly the Committee proposes that a new initiative described below be funded by the Agency.

New Initiative in Wastewater Process Development

The proposed initiative has four components:

- More cost-effective phosphorus control technology
- Assessment of the need for ammonia removal and nitrogen management
- Establishment of a Research Center for Small Wastewater Flows
- Development of improved biological treatment systems.

Details of the four elements are discussed below.

1. More Cost-Effective Phosphorus Control Technology

The phosphorus management strategic task force of the International Joint Commission (IJC) on the Great Lakes has concluded that the lower Great Lakes (Ontario and Erie) will not meet water quality objectives as

Table IV-1a Wastewater Process Development — New or Improved Biological Process Development, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. **Upgraded Lagoon Treatment by Simple, Low-Cost Methods** Outputs: a) Reports on algae removal using slow rock and intermediate sand filters; b) Lagoon upgrading design manual		a	b				
2. **Efficient O_2 Transfer to Biological Systems** Outputs: a) European survey of fine bubble diffusers; b) Full-scale evaluation of activated biofiltration system; c) Clean water evaluation of submerged air aeration equipment; d) Standard/procedural manual for conducting and evaluating O_2 transfer test; e) Large-scale evaluation of deep shaft activated sludge system; f) Large-scale evaluation of reactor/clarifier activated sludge process; g) Field-scale dirty water evaluation of new, high-efficiency submerged air aeration equipment.		a b	c d	e f	g		
Outputs: a) Survey to develop interim RBC design guidelines; b) National symposium on RBCs; c) Field study to develop RBC design criteria.		a	b		c		II (Region VII)
4. **Evaluation of Batch Reactors and Fluidized Bed Reactors** Outputs: a) Full-scale study of sequencing batch reactors; b) Full-scale evaluation of fluidized bed reactor on carbonaceous material			a			b	
R & D Resouces		850	895	965	685	710	

Table IV-1b Wastewater Process Development — Biodegradation and Specific Pollutant Removal, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. **Biodegradation Studies of Priority Pollutants (PP)** Outputs: a) Interim report on biodegradation protocols for selected PP; b) Lab study of static biodegradation of PP; c) In-house continuous flow studies of PP		a	b c				4 (OWPO, OWE)
2. **Nutrient Removal** Outputs: a) Analysis of P removal in Great Lakes; b) International nutrient control seminar; c) Design manuals on nitrogen (N) and phosphorus (P) removal; d) Feasibility study of low cost, low residual P removal process; e) Evaluation of Barden PHO process; f) Field evaluation of process described in (d).		a b		c	d e	f	5 (Region I)
R & D Resources		737	500	500	380	320	

Table IV-1c Wastewater Process Development — Microbiological Control, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. **Chlorination and Dechlorination** Outputs: a) Report on optimization of chlorination process	▲ a						9, 10, 12, 13 (Regions V, VIII, X)
2. **Ozonation** Outputs: a) Application of ozone for stringent coliform criteria; b) Report on techniques for ozone measurement; c) Evaluation of ozone for disinfection and trace toxic organics control.			▲ a ▲ b			▲ c	4, 8, 10 (OWPS, OWE Region V)
3. **Ultraviolet Light (UV)** Outputs: a) Full-scale demo of 1st generation UV light disinfection of wastewater; b) Evaluation of UV for disinfection and trace organic control.			▲ a			▲ b	4, 8, 10 (OWPS, OWE Region V)
4. **Chlorine Dioxide (ClO_2)** Outputs: a) Comparison of ClO_2 to chlorine for municipal use.		▲ a					8, 10 (Region V)
5. **Disinfection of Antibiotic-Resistant Organisms** Outputs: a) Report on occurrence of antibiotic-resistant coliforms; b) Effectiveness of disinfection upon resistant organisms.				▲ a		▲ b	9 (Region V)
6. **Disinfection SOA Technology Transfer** Outputs: a) Report on risk-benefit-cost of alternate disinfection; b) Disinfection evaluation manual.			▲ a			▲ b	3, 8, 9, 10, 13 (OWPO, (Regions V, VIII, X)
R & D Resources		753	625	630	520	520	

agreed by treaty without municipal point and non-point source controls. The limited opportunities for non-point source control in the Lake Ontario basin suggest that most additional phosphorus reduction be accomplished through further municipal control to levels of 0.1 to 0.5 mg/l in the effluent (as opposed to the current requirement of 1 mg/l).

In the Lake Erie basin non-point source control requirements range from 1000 to 5000 metric tons per year. The cost-effectiveness of controls and the resolution of what can be achieved within reasonable economic bounds are issues of major concern. Assuming that a reduction of about 2000 metric tons per year of phosphorus can be achieved economically through non-point source controls, water quality objectives for the basin can be met with a level of municipal point source control of 0.3 mg/l.

It is essential that the targeted reduction in Lake Erie be met to bring inter-basin transfers of phosphorus to Lake Ontario down to levels enabling attainment of water quality objectives in that lake. Technology developed under this initiative is also expected to find application in other areas such as Reno, Nevada and Tampa Bay, Florida. This component is estimated to cost about $500 K per year beginning in 1982 and will require no additional research positions.

2. Assessment of the Need for Ammonia Removal and Nitrogen Management

Un-ionized ammonia (NH_3) is being considered as the 66th priority pollutant for regulation. Many municipal treatment plants may have to alter their control technology to achieve the 20 ug/l ammonia standards based on the Water Quality Criterion for un-ionized ammonia. The Agency is also proposing that ammonia be added to the toxic pollutants list (Federal Register, January 3, 1980). This may create a market for nitrification processes (and other manipulations) to meet un-ionized ammonia discharge standards. Likewise, recent evidence that salmonoid fishes are adversely affected by relatively modest in-stream concentrations of nitrate emphasizes the need for greater attention to nitrogen management overall. An assessment is needed to determine the levels of un-ionized ammonia at which adverse in-stream effects can be observed and the level of control achievable with current technology. The assessment would also include a determination of what upgrading of municipal wastewater management techniques can be used to meet the standard. Further research efforts would await the results of this assessment which would begin in 1982 for about $250 K per year and no additional positions.

3. Research Center for Small Wastewater Flows

In order to focus the proper attention and resources on high priority requirements regarding small wastewater flows (SWF) the Committee recommends that the SWF Clearinghouse be moved from CERI to MERL as part of the establishment of a Research Center for Small Wastewater Flows. This component of the initiative would require about $500 K per year and no additional positions.

4. Development of Improved Biological Systems

The CWA provisions for the Innovative and Alternative Technology attempt to accelerate the use of emerging treatment technologies. In order to "prime the pump" in support of the development of additional biological processes, ORD will need additional resources. Candidate technologies for development include:

- Deep shaft aeration
- Natural systems (wetlands, aquaculture, land treatment, etc.)
- Fluidized bed aerobic processes
- Anaerobic process options (including fluidized bed and fixed-film reactors.

This component would involve $1 million per year and one additional research position.

Response to Stated Research Requirements

Of the thirteen research requirements for wastewater process development identified in Section III, four (1, 2, 6 and 7) appear not to be addressed by the planned research program. The first two, involving energy conservation in POTWs are the subject of a major ORD initiative proposed under the Plant Operation and Design research effort. Requirement #6, requesting a study of electron irradiation of wastewater, is presently under consideration by ORD as part of the Microbiological Control objective. Requirement #7, methods to correct nitrate accumulation in groundwaters, is to be addressed subsequent to discussions between this Committee and the Drinking Water Research Committee.

2. TOXIC POLLUTANTS CONTROL

This research area supports agency efforts to comply with both legislative and judicial requirements to control the release of toxic metals and organics to the environment. Section 307 of the Clean Water Act Amendments (PL 95-217), based on the results of the NRDC Consent Decree, established a priority list of 129 toxic pollutants for which effluent limitations must be set for 27 categories of point source dischargers. The Act also allows consideration of the efficacy of toxics removal at POTWs in the setting of pretreatment standards for industrial dischargers introducing toxic pollutants into a POTW.

Although these legal requirements are basically directed toward the control and abatement of industrial point sources, they involve a significant commitment to municipal wastewater research on toxics control due to the large number of industrial dischargers to municipal collection systems.

Agency Research Requirements, Priorities and Future Directions

Specific research requirements were presented earlier in Section III; in general they involve assisting the operating programs, largely the Office of Water Planning and Standards (OWPS) and the Office of Water Program Operations (OWPO), to assess the magnitude and composition of toxics in wastes received and discharged by publicly owned treatment works (POTWs) and to conduct an urban-wide mass balance (source partitioning) of toxic substances and hazardous wastes. Continued research efforts are needed to expand data collection activities to quantify the source and magnitude of the toxics problem in municipal wastewaters. This information will be used in the development of a systems analysis approach on the overall impact of source control of toxics by pretreatment versus treatment and/or detoxification at the POTW.

Another important area to be emphasized is the development of procedures which will allow for rapid determination of biodegradability and/or treatability of a chemical in a POTW system. This information will also be used to develop a treatability manual in conjunction with a manual establishing pretreatment credits for use by municipalities. ORD has established a Treatability Coordination Committee to oversee the preparation of a Wastewater Treatability Manual. The Committee has members from four laboratories, CERI and the cognizant Program Offices. The manual, comprising several volumes, is nearing completion.

Overview of Objectives

The toxics control research effort has three major objectives:

- Development of data bases on priority pollutants in terms of sources contributing to POTWs, occurrence and concentration in POTW influents, effluents and sludges, and removals obtainable by unit processes.
- Development and evaluation of treatment processes which enhance the removal of priority pollutants from wastewater. The degree of research effort on treatment processes will be tailored to the problem as revealed in the first objective.
- Assessment of treatability and removability of priority pollutants by a variety of conventional and AWT processes. Processes receiving initial attention are, carbon adsorption biodegradation and, desorption by "stripping."

These objectives all focus on the primary goal of characterizing the toxic pollutants in municipal systems and developing control options and technologies to prevent or control the discharge of toxic pollutants into the urban environment.

ORD Plans and Activities

Table IV-2 summarizes planned research in the control of toxic pollutants by presenting the time-frame within which objectives and subobjectives will be accomplished. As is apparent from the table, priority requirements described earlier are being addressed within a broad-based research program. Unaddressed requirements are discussed in the following section.

Response to Stated Research Requirements

Of the 26 research requirements identified in Section III, nine (Nos. 2, 8, 10, 15, 19, 21, 22, 24, 25) are not directly addressed by planned ORD research. Of the ten, one (#8) is a request to Technology Transfer support and four (Nos. 2, 15, 19, 22) relate to the protection of water quality. ORD plans to provide Technology Transfer support as a part of on-going research activities rather than as a separate line item in its budget and thus will address this need within the context of the research effort laid out in Table IV-2. The four requirements related to water quality protection require further coordination with the Water Quality Research Committee.

Requirement #10 (Protocols for sampling and testing) is the subject of discussion with the Toxics Testing and Assessment Committee and requirement #21 (Analyze institutional impediments to pretreatment) is presently unaddressed; prospective ORD approaches to this problem are to be explored with OWPS.

Requirement #24 (Assessment criteria for BMPs), while not explicitly addressed within the current research effort, is a consideration in some of the projects being carried out under the R&D objective entitled "Toxics Data Base: Generation, Management and Indicator Development." See outputs 1b and 1f in Table IV-2 for example. Additional discussions with OWE will be necessary to refine the research effort in this area.

Requirement #25 (Information on POTW and on-site non-industrial toxics) is partially satisfied by on-going research into POTW toxics. However, data on toxics from on-site systems is more likely to be developed at a later time.

3. MUNICIPAL SLUDGE MANAGEMENT

The Agency's regulations and policies result from implementation of the Marine Protection Research and Sanctuaries Act, the Clean Air Act, RCRA and the 1977 Clean Water Act (CWA). RCRA addresses land disposal and beneficial utilization of solid waste including sludge by establishing criteria for acceptable land disposal systems to preclude degradation of the environment through improper disposal of sludge. Section 201 of the CWA requires "the ultimate disposal of sludge in a manner that will not result in environmental hazards." The CWA also addresses the fate of toxics in POTWs and the establishment of guidelines on the proper utilization and disposal of municipal sludges by POTWs (Sections 307 and 405).

Table IV-2 Toxic Pollutants Control, R & D Outputs and Resources
(Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. **Toxics Data Base: Generation, Management and Indicator Development** Outputs: a) Data generation in 25 city survey; b) Computerized cost optimization model for urban toxics control strategies; c) interim reports on toxics at POTWs (survey), analysis of influents, effluents and sludges; d) Compendium and assessment report; e) Test of alternative indicator approaches; f) Risk assessment model for meeting regulations under various control strategies.		▲ a	▲ b △ c ▲ d			▲ e f	1, 5, 6, 9, 11, 12, 13, 14, 16, 17, 18, 20, 26 (OWPO, OWPS, OPTS, Region V)
R & D Resources		380	285	355	315	315	
2. **Toxics Removal Process Evaluation and Development** Outputs: a) T & E facility toxics work; b) Toxic stripping from aeration basin; c) Improved analytical techniques for organics extraction from wastewater and sludges; d) Cadmium and metals removal by lime precipitation; e) Biological modification studies; f) Improved analytical clean-up techniques for increased sensitivity and precision; g) Evaluation of ozone/carbon adsorption toxics removal; h) Biological treatment modification by adding adsorbents; i) Additional improvements and new procedures from other projects; j) Additional studies on full-scale plants.			▲ a b c d	▲ a e f g		▲ h i j	3, 4, 7, 9, 18, 23 (OWPO, OWE OWPS, OPTS)
R & D Resources		955	730	905	1015	1015	
3. **Toxics Treatability** Outputs a) Progress on reports on biodegradation lit survey, carbon adsorption structure-activity analysis and organics stripping model; b) Carbon adsorption treatability and modeling, c) Biodegradability of priority pollutants (start in FY 80)		▲ a	▲ b			▲ c	3 (OWPO, OWE, OWPS, OPTS)
R & D Resources		610	417	510	505	485	

Agency Research Requirements, Priorities and Future Directions

In order to be responsive to agency requirements, R&D efforts in sludge management should continue in their current direction with primary focus on the resolution of potential health problems and the development of effective sludge management technologies. While specific needs were identified earlier in Section III, several generic needs are worth highlighting here. More information is needed on the potential health hazards presented by organics, pesticides, lead, cadmium and other metals in sludge. Particular emphasis has been requested on the presence and behavior of lead and cadmium in municipal sludges used in landspreading operations and efforts here need to be coordinated with the Food and Drug Administration.

Further characterization of the potential health hazards associated with sludge incineration, specifically hazardous materials in the ash and the emission of pollutants to the atmosphere, also needs to be undertaken.

More in-depth evaluations of various processes for sludge treatment, handling, disposal and utilization are necessary to facilitate the approval of projects under Construction Grants including those proposed as "Innovative and Alternative" technology. Processes of interest include composting, anaerobic digestion, metals extraction and vermiculture.

In the area of land application of sludges, ORD proposes to develop a methodology for the protection of groundwater from priority pollutants and sludge disposal to land. High-rate application methods such as landfilling will be evaluated in addition to lower rate systems. Work in this area is proposed as a new initiative and is discussed further below.

Overview of Objectives

The goal of research in this area is to develop methods of processing, using, and disposing of sludge in the most cost effective and environmentally satisfactory manner. There are three components to this program:

- Processing and stabilization
- Conversion and energy recovery
- Land application management and land disposal

These three major components are described below.

Processing and Stabilization

This area includes thickening, stabilizing, conditioning, disinfecting, and dewatering of sludge. Research efforts into new technologies focuses on their ability to reach the desired processing objective, their reliability, cost, and energy requirements. There are a number of projects presently underway within the processing and stabilization area. For example, studies are being conducted to evaluate and compare the performance and cost of various thickening and dewatering devices as well as to evaluate the efficacy of sludge disinfection. Reports on the state-of-the-art and costs and benefits of disinfection as well as demonstration of new methods for stabilization that also disinfect are in progress. Various novel approaches to energy recovery in aerobic and anaerobic digester operation and generation of power from digester gas are also being evaluated. Finally, processes that will remove or bind toxic metallic or organic pollutants in sludge economically are under investigation.

Conversion and Energy Recovery

The objective here is to change sludge to a form which is more easily disposed while recovering energy to the degree practicable and which permits its safe disposal or utilization on the land. Conversion also reduces the volume of sludge for disposal significantly. Starved-air combustion, a process that utilizes the heat content of sludge alone or with added fuel from refuse or other sources to complete the conversion process, is presently being evaluated. Coincineration utilizing refuse to upgrade the heating value of sludge is also under study. Also in this area, research and development is in progress to characterize the emissions from conventional sludge incineration and incinerators operating under starved-air conditions and to investigate the fate of metals in incineration. Evaluations of European within-vessel and other composting processes are being conducted as well.

Land Application Management and Disposal

Land application of sludge is increasing despite persistent concerns expressed about potential health and ecological effects of some sludge components. Research subobjectives aimed at obviating these concerns include:

- Determining the impacts of toxic organics and heavy metals on crop response and site life.
- Develop sludge management practices for land application systems.
- Assess the use of sludge for land reclamation, energy and production of biomass and other non-food chain crops.
- Assess the long-term impacts of high-rate sludge application on soil.

ORD Plans and Activities

Planned ORD research activities through 1984 are summarized in Tables IV-3a through 3c. Outputs listed on the left-hand side of the charts are described in greater detail in the LOP for Sludge Management. The tables outline a comprehensive plan of research that is very responsive to the stated needs identified earlier as well as to the guidance provided by the Program Offices (primarily OWPO) over the last several years. However, the Committee

Table IV-3a Sludge Management — Processing and Stabilization, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. Dewatering and Conditioning Outputs: a) Yearly report on cost, performance and design data on thickening and dewatering; b) SOA report on chemical sludge handling; c) Evaluation of devices for producing high-solids cake; d) Tech. assessment for dewatering to high-cake solids; e) Data on top-feed rotary vacuum filter; f) Full-scale evaluation of dewatering devices; g) On-site studies in thickening and dewatering.	a c	b a	d a f	e g			1, 8 (OWPO)
2. Disinfection and Stabilization Outputs: a) Purifax Evaluation Report; b) SOA report on lime stabilization; c) SOA report on Vermi composting; d) Report on detoxification by aerobic thermophilic digestion; e) Report on pathogen survival in aerobic digestion; f) Evaluation of new and innovative methods; g) Report on gamma ray irradiation for stabilization; h) Procedure for characterizing sludge stability; i) Solids separation without 2nd stage digestion.		a b c d	e f h	g i			20, 24, 25, 31 (OSW, Regions I, VIII)
3. Energy-Related Sludge Technology Outputs: a) SOA report on costs and benefits; b) Report on improved anaerobic digester and energy production; c) Solar energy and digester gas use demo; d) OTAM* digestion demo; e) Demo of modular gas turbine for POTW energy.		a	b c	d e			2, 22, 27 (OWPO, OSW, Region I)
4. Toxicants Removal Outputs: a) Report on heat and acid treatment for conditioning heavy metals removal; b) Assessment of present technologies for heavy metals removal; c) Heavy metals removal by centrifugal classification; d) Pilot-scale test of heavy metals removal process.		a b	c	d			13, 14 (OWPS, OPTS, OWE)
R & D Resources		1060	900	910	905	907	

* Oxygen thermophilic plus anaerobic mesophilic digestion (Higher temperature oxygen enriched digestion followed by lower temperature, oxygen deficient digestion)

Table IV-3b Sludge Management — Conversion and Energy Recovery R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. **Evaluate Thermal Processes and Energy Recovery** Outputs: a) Evaluation of co-incineration project; b) Evaluation of 2nd co-incineration process (with OSW); c Evaluation of pyrolysis with RDF addition and high-solids cake.		a				b c	3, 4, 5 (OWPO)
2. **Characterize Emissions from Sludge Disposal Facilities** Outputs: a) Reports on sludge incinerator emissions; b) Evaluation of incinerators with best SOA pollution control devices; c) Study of advanced technology for controlling emissions from thermal conversion processes; d) Summary report on incinerator emissions and evaluation of advanced control technologies.		a	b		c	d	6 (OWPO, OPTS)
3. **Evaluate Composting and Other Conversion Processes** Outputs: a) Report on European technology and leading within-vessel process; b) Additional evaluations; c) Report on composting on a barge; d) Demo of unique U.S. composting process.		a	b c	d		c	4, 10, 28 (OWPO, Region II)
4. **Study Emerging Resource Recovery Processes** Outputs: a) Evaluation of wet oxidation in a deep-well reactor; b) Contractor evaluation of deep-well wet oxidation; c) Feasibility study of liquefaction of sludge to produce synthetic asphalt; d) Evaluate operation of asphalt plant.		a		b	c	d	4 (OWPO)
R & D Resources		1070	1195	1050	1650	1760	

Table IV-3c Sludge Management — Land Application Management and Disposal, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. Impacts of Toxicants on Crop Response and Site Life Outputs: a) Chemistry of metals in sludge-amended soils; b) Effects of long-term use; c) Sludge utilization on sandy coastal plains; d) Crop response to various application rates and soil types of Eastern U.S.; e) Impacts of prolonged application of various rates; f) Cumulative loadings of metals vs. annual sludge application; g) Soil factors affecting metal absorption; h) Approved method for sampling and analysis; i) Report on toxics in sludge; j) Fate & effects of toxic organics in sludge applied to agricultural land; k) Effects on selected crops of long-term sludge use under various mgmt. schemes; l) Crop uptake of metals under various soil properties.		a b c	d e f g	h i	j k	l	9, 12, 15, 16, 17, 19, 21, 23, 29 (OWPO, OWPS, OWE, OSW, Regions I, V, VI)
2. Sludge Management Practices for Soil Systems Outputs: a) Effects of long-term sludge application; b) Sludge use in sandy coastal plain soils; c) Demo of sludge use to relcaim acidic mine spoils; d) Fate/effects of nutrients under various methods for Eastern U.S. soils; e) Effects of accumulation of sludge from several years of application; f) Proper site management on agricultural soils; g) Nutrient transformations in sludge-amended soils; h) Demo of best available technology for using sludge as fertilizer on farms; i) Fate/effects from various land application mgmt schemes.		a b c	d e f	g	h	i	7, 23, 32 (OWPO, Regions I, VI, IX)
3. Assess Fate and Effects of Pathogenic Organisms Outputs: a) Static pile composting; b) Helminth transmission from sludge use; c) Pathogen requirements for RCRA; d) Demo of beneficial use of sludge on farms (incl. epidemiological study); e) Parasites in sludge; f) Effectiveness of sludge storage in diminishing parasitic ova; g) Fate of viruses in sludge treated soil.		a b c		d	e f	g	20, SM-5*, SM-8* (OSW, Regions I, VII)
4. Assess the Use of Sludge for Energy & Other Non-Food Chain Crops Outputs: a) Sludge use in a western forest; b) Feasibility of energy crop production with sludge; c) Non-food chain crops from sludge; d) Use of sludge to produce turf grass; e) Sludge use to grow trees in Eastern U.S.	a	b c			d e	d	22, 30 (OSW, Region VIII)
5. Assess Long-Term Impact of High Rate Application on Soil Outputs: a) Use of sludge to reclaim acid mine spoils; b) Comparison of infrequent large application with numerous smaller ones; c) Assessment of high rate application; d) Evaluation of sludge landfilling; e) Mgmt. document for sludge use in mine reclamation.		a	b	c	▲	e	7, 15, 17, 23 (OWPO, OWPS, OSW, Regions I, VI)
R & D Resources		1550	1550	1550	1550	1550	

*Health effects research requirements for sludge management from Table III-II has identified the need for promoting land application of sludge and for evaluative research into the impact of sludge application upon groundwater as discussed below.

Evaluation of Beneficial Use and High-Rate Land Application of Sludge

This initiative emphasizes the promotion of land application of sludge through cooperative programs developed in several states. Three cooperative programs based on the "Ohio Plan" (Farm Bureau Cooperative Agreement) would be set up by working through farm groups and agricultural extension services. About $1 million per year and no new positions would be required.

The second component of the initiative aims at developing a methodology for relating the concentration of priority pollutants in sludge disposed to the land to the attainment of interim primary drinking water standards for groundwater. This would require about $750 K per year through 1984 and two additional research positions. It is anticipated that the work would involve the ORD Test and Evaluation Facility in Cincinnati as well as contractor efforts.

Response to Stated Research Requirements

No major gaps appear in ORD's response to the 33 identified research requirements. Four requirements (Nos. 11, 18, 26, 28a) require discussion here. The first, a low priority request to "Evaluate ash disposal and extraction from incineration" is under discussion with the Program Office (OWPO) to determine the utility of research efforts being carried out on incinerator ash leaching and identify any necessary restructuring of activities.

Requirement #18 (PCB persistence, adherence to crops, uptake and retention) reflects the growing concern over PCBs within the Office of Solid Waste (OSW). More discussion on the topic is planned between ORD and OSW to delineate research requirements.

Requirement #26 (Assist the University of Connecticut study of sludge application to corn crops) is satisfied by several on-going and completed ORD projects, including the Fulton County, Illinois study, focusing on the effects of land application on various crops including corn.

Requirement 28a (Acceptability of landspreading and thermal destruction of urban sludges) is to be partially addressed under a new initiative described later in the section on Innovative and Alternative Technology (since landspreading is considered alternative technology). ORD will discuss with Region II details of its request with regard to thermal destruction to ascertain appropriate response.

4. PLANT OPERATION AND DESIGN

The ORD plant operation and design program supports the construction grant Step I, II, and III process (O&M Manuals, plant operation, start-up provisions, etc.). The program assists EPA Regions and Headquarters with information/assistance in O&M document reviews, O&M inspections, and performance evaluations

EPA activities involving support to the states include POTW operator training under Section 104(g)(1) and Section 109(b), NPDES permits issuance/compliance, inspections, and enforcement actions.

Agency Research Requirements, Priorities and Future Directions

Municipal wastewater treatment plants constructed with EPA funds have been experiencing operational problems to such an extent that the General Accounting Office (GAO) estimates that fully one-third to one-half of the plants constructed with federal funds are unable to achieve their design performance criteria. Spurred by these preliminary results, EPA is presently conducting an investigation into the operational difficulties being encountered by the plants and the need for immediate, effective, remedial measures. The ORD research effort in plant operation and design recognizes the various dimensions of this problem and is addressing it in several ways.

Among the most urgent research requirements are the development of procedures to improve the design, cost, and energy effectiveness of new and upgraded wastewater treatment plants, improved methods to assure proper performance of existing facilities through improved operation and maintenance and increased system and subsystem reliability and the application of instrumentation and automation to process control and system management.

A recently completed protocols for conducting comprehensive plant performance evaluations, will be used with a design deficiency matrix (available in two months) to enable plant design personnel to optimize the operation and maintenance of biological treatment facilities. Operational problems and design deficiencies in handling, treatment and disposal systems will be an important focus of the research effort. The near-term goal will be to develop recommendations for solutions of problems and for process modifications to improve system performance, reliability, and cost effectiveness.

Overview of Objective

Broad objectives of the program are to reduce the construction and operational costs of POTWs and to improve baseline performance and reliability of POTWs. These goals are supported by the three major subobjectives of the research effort:

- Analysis of operational design factors affecting performance
- Remedial methodology development
- Energy use in wastewater treatment facilities.

ORD Plans and Activities

Planned research activities for 1980 through 1984 are presented graphically in Table IV-4. As before the left-hand side of the chart identifies projected outputs based on the Laboratory Output Plan (LOP). As the chart indicates

Table IV-4 Plant Operation and Design, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D NEED ADDRESSED
1. **Analysis of Operational Design Factors Affecting Performance** Outputs: a) National O & M cause and effect survey; b) Protocol for comprehensive plant evaluations; c) Design guidelines for conventional systems; d) Computerized performance and O & M data base. e) Land application/alternative technology guidelines; f) Composite correction program for improving POTW performance.	a	b	c d e f	c e	e f		1, 2, 6, 9 (OWPO, Regions, I, III, IV, VIII)
R & D Resources		710	584	295	304	305	
2. **Remedial Methodology Development** Outputs: a) Composite correction program for improving POTW performance; b) Process control strategies for wastewater and residuals; c) Process and systems reliability report; d) Demo of automation and in-process control strategies; e) Centralized management strategies for small plants.	a b	b c c d	b a e	b a c	d		2, 3, 5, 8 (OWPO, OWPS, Regions I, V)
R & D Resources		740	975	622	865	880	
3. **Energy Use in Wastewater Treatment Facilities** Outputs: a) Energy conservation in reuse, recycle and conservation; b) Energy assessment procedures manual; c) Report on energy effectiveness-wastewater and residuals.		a	b		c		4, 5 (Region I)
R & D Resources		250	250	250	400	400	

the research effort attempts to be responsive to GAO concerns over operating deficiencies of new treatment plants as well as the specific requirements identified by Regional and Headquarters Offices.

Energy is one of the key criteria for funding eligibility under the CWA and the Municipal Environmental Research Laboratory (MERL) has recently been given the responsibility for doing energy-related research for municipal treatment plants. Also the Office of Water Program Operations has requested ORD to take on a more active role in doing research on energy conservation and recovery techniques and to propose them during I&A project reviews as a way of stimulating greater energy conservation and recovery. Consequently, the Committee proposes a new initiative aimed at the development of methods and techniques for achieving energy savings at POTWs. Cost of the initiative is estimated at $750 K per year beginning in 1982 and one additional research position.

Response to Stated Research Requirements

Of the eleven research requirements identified earlier, three (Nos. 7, 10, and 11) appear not to be addressed within the current research plan. Requirement #7 (Refresher courses for operators) would require funds well in excess of ORD's current resources in this area. Training activities are currently carried out by OWPO through the National Training and Operational Technology Center. Requirement #10 (Improved supernatant quality in anaerobic digestion) will be handled in discussions between the affected regional office (Region VIII) and ORD researchers at the Municipal Environmental Research Laboratory (MERL). Resolution of requirement #11 (Reliability of ammonia-nitrogen reduction in cold climates) will be covered in discussions with MERL personnel.

5. LAND APPLICATION OF WASTEWATER AND AQUACULTURE

Aquaculture has been added to the last portion of this section because the subject is part of the R. S. Kerr Laboratory (RSKERL) research. The first part of this section will discuss the land application research effort.

LAND APPLICATION OF WASTEWATER

Legislation and EPA policy clearly support increased use of land treatment practices. The CWA encourages the construction of agriculture, silviculture, or aquaculture projects. In November 1974, it became agency policy that applications for construction grants were required to include consideration of land treatment as an alternative. In October 1977 it became a requirement for Construction Grant Projects to provide complete justification for the rejection of land treatment if a method that encourages waster conservation, wastewater reclamation and reuse is not recommended.

Agency Research Requirements, Priorities and Future Directions

In order to address the specific requirements stated in Section III there is a need to undertake additional studies of the transport and transformation of pollutants in soils with emphasis upon the priority pollutants.

More needs to be known about the long-term effects of land treatment upon the soil media and groundwater resources, with development and use of predictive models. Improved methods for field measurement of soil properties should also be developed and provided for use by local regulatory agencies.

The regional offices and state regulatory offices have an urgent need for guidance relating to the degree of pretreatment necessary prior to land treatment. Controversy exists concerning the need for and value of disinfecting municipal wastewater before applying it to the land. This primarily concerns potential health impacts and research directed toward resolving this area of concern will be implemented.

Overview of Objectives

The five major objectives of this area of research are:

- Development of reliable design and operating criteria for nationwide application of the three land treatment processes (slow rate, rapid infiltration, and overland flow).
- Clarification of fundamental mechanisms involved in plant-soil-water relationships so that more efficient operation can be achieved.
- Development of operating and management practices to minimize or prevent any adverse effects of system operations.
- Transfer and dissemination of the information to regulatory agencies, municipalities, engineers, and other potential users.
- Cooperative liaison with on-going research in health effects, land application of sludge, and groundwater quality.

ORD Plans and Activities

R&D outputs planned for 1980 through 1984 are summarized in Table IV-5a for land application. Program resources projected by fiscal year are also indicated (in constant 1980 dollars) and the stated R&D requirements addressed by the outputs are listed.

Major near-term outputs of the research effort include the revision of the process design manual for land treatment of municipal wastewater, the completion of the land treatment task force report and the evaluation of various land treatment systems.

The Committee recommends the adoption of a new initiative in this area in order to respond to increased Agency emphasis on the use of natural treatment systems. The new research effort would focus on the development of natural systems for wastewater treatment including land application, the use of wetlands and aquaculture. Cost of the effort is expected to be about $1 million per year beginning in 1982 and no additional positions.

Table IV-5a Land Application of Wastewater, R & D Outputs and Resources
(Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. **Land Treatment Task Force** Outputs: a) Task Force report.			▲a				7, 8 (OWPO)
2. **Assessment of Long-Term Effects from Six Slow-Rate Systems** Outputs: a) Summary report on existing slow-rate systems			▲a				4, 8, 11, 22 (OWPO)
3. **Lubbock Demonstration of Slow-Rate Irrigation** Outputs: a) Construction complete; b) Research reports; c) SOA report on slow-rate land treatment.		▲a	▲b	▲b	▲c		4, 21 (OWPO, Region VIII)
4. **Assessment of Long-Term Effects From Four Rapid Infiltration Systems** Outputs: a) Summary report of existing rapid infiltration systems.		▲a					6, 8, 11 (OWPO)
5. **Develop, Design and Operating Criteria for Overland Flow Systems** Outputs: a) Interim criteria report; b) Final criteria incl. Northern climates			△a			▲b	3, 20 (OWPO, Region V)
6. **Develop Design and Operating Criteria for Rapid Infiltration Systems** Outputs: a) Revised design criteria; b) Design criteria for environ. controlled systems.			▲a			▲b	6 (OWPO)
7. **Evaluate Design and Operation of Slow-Rate Systems** Outputs: a) Revised design and operating criteria.				▲a		▲a	9 (OWPO)
8. **Develop Mathematical Model for Determining Kinetics and Reactions of P in Soils** Outputs: a) Report on model.			▲a				18 (Region I)
9. **Nitogen Management Model** Outputs: a) Interim reports; b) Final model for N-mgmt. in soil treatment.				△a	▲b		13, 18 (Region I)
10. **Soil Transport and Transformation of Toxic Substances** Outputs: a) Series of reports on toxic substances interaction with soils; b) Predictive models.			△a	△a	△a	△a ▲b	4, 12, 13, 14 (OWPO, OWPS, Region I)
11. **Case Studies of Land Treatment Systems** Outputs: a) Reports on 10 systems	△a	▲a					8, 11 (OWPO)
12. **Land Treatment Design Manual** Outputs: a) Revision of process design manual for land treatment of municipal wastewater.			▲a				1 (OWPO)
R & D Resources		729	942	725	560	555	

Response to Stated Research Requirements

Of the twenty-two identified research requirements, five (Nos. 2, 15, 16, 17 and 19) appear to be unaddressed by planned research effort.

Requirement #2 (Efficacy of preapplication treatment by lagoons, ponds, etc.) is the topic of much discussion within ORD on, basically, the degree of treatment prior to land application. Requirements #15 (Determine safe distances from water supplies), #16 (Methods of sampling at aquifer interface), and #19 (Effect of wastewater injection on groundwater quality) are to be covered in discussions with other cognizant Research Committees. At this time there is no one Committee with central responsibility in the groundwater area. A parallel look at this issue with regard to landspreading of sludge is recommended as a new initiative, described earlier, in Municipal Sludge Management.

Requirement #17 (Design criteria, cost of evapotranspiration systems) may be addressed by on-going research projects but additional discussions are needed with the Regional Office (Region I) to ascertain the applicability of the efforts.

AQUACULTURE PROGRAM

The 1972 Act (PL 92-500) and the 1977 amendments clearly give impetus to the development and use of aquaculture treatment of municipal wastewater.

Agency Research Requirements, Priorities, and Future Directions

Wastewater aquaculture is a viable research area having large potential for application to environmental problems. In order to develop processes for wastewater treatment or reuse, however, it will be necessary to evaluate a variety of criteria such as loading, pretreatment requirements, stocking and harvesting rates, product processing and utilizations, acceptability of species, climatic factors, and economy of operation. Wastewater aquaculture is very broad in scope, involving a variety of organisms, both freshwater and marine environments, organized treatment processes, and wastewater recycling by inputs into natural aquatic habitats.

Overview of Objectives

Aquaculture research is directed toward the development of natural systems for the treatment and management of wastewaters. Aquatic organisms or habitats of interest include natural and man-made wetlands, vascular plants, invertebrates, finfish, shellfish, and various combinations of such systems. Emphasis has been placed on development of these biological/ecological systems as polishing units following primary or secondary treatment, for use in upgrading lagoons and, in some cases, as complete treatment systems. The approach under this subobjective is twofold: exploratory research to identify promising systems, and developmental research for those systems having the most potential for early utilization.

Emphasis is placed on development of systems which have the greatest potential for early payoff. Research of an exploratory nature aimed at identifying those systems for future developmental concentration is also conducted. Consideration is given to economic factors, potential resource recovery and reuse, potential for production of a valuable product and possible energy conservation.

ORD Plans and Activities

Specific on-going and planned ORD activities are detailed in Table IV-5b. As shown in the Table, the RSKERL aquaculture research program is concentrating on basic data needed to design and operate aquaculture treatment facilities properly. The state-of-the-art is in its infancy, and budgeted resources are relatively small. Efforts are being concentrated, therefore, on the most promising methods, particularly water hyacinths and artificial wetlands. Coordination between EPA and other agencies in aquaculture is maintained through membership in the Joint Subcommittee on Aquaculture and several of its panels including Regulation and Effluent Utilization. The aquaculture research effort would, of course, be significantly broadened by the natural systems initiative described earlier in this section.

Response to Stated Research Requirements

Few research requirements directed explicitly at wastewater aquaculture were noted in Section III although it should be noted that most of the general land treatment requirements also apply to aquaculture systems as well. Several limitations of the present plan due largely to resource constraints have been noted, however. Among these are the fact that little data will be obtained on removal of priority pollutants by aquaculture treatment; nor will macrophytes other than water hyacinths be extensively investigated. Finally, it appears that research will concentrate on artificial wetlands as opposed to natural wetlands. It is anticipated that the maturing of the research effort in this area will allow its extension to these key areas.

6. URBAN RUNOFF

The control of urban stormwater runoff and combined sewer overflows (CSO) is an important element of the overall approach to attainment of the goals of the Clean Water Act and its Amendments. In order to facilitate the formulation of Agency policy and planning the Office of Water Program Operations conducted a specific CSO "Needs Survey" in 1978 and is presently doing an intensive evaluation of cities which are planning or have done CSO remedial work. This will be incorporated in a report to Congress with appropriate recommendations. The report is due in February 1981. Additionally, the National Urban Runoff Program (NURP) has been established within the Office of Water Planning and Standards. NURP plans to capitalize on the effort carried out under Section 208 planning grants and technology developed by the R&D program to characterize urban non-point source problems and solutions by conducting about 30 projects across the country. The ultimate objective of the program, which is demonstrate in nature, is to conduct an assessment of urban runoff impacts and control technologies on a nationwide scale and present the findings in a report to Congress in 1983.

Table IV-5b Aquaculture and Wetlands, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. **Evaluate the Use of Fish Species in Wastewater Treatment** Outputs: a) Assessment report for indigenous fish species; b) Assessment report for exotic fish species.	━━━	━━━	▲ a ━ ▲ b				5, 10 (OWPO)
2. **Evaluate Effectiveness of Water Hyacinths for Treating 1° and 2° Effluent** Outputs: a) Preliminary design criteria for water hyacinth treatment; b) Evaluation of environmental control units; c) Evaluation of hyacinth harvesting and utilization.	━━━	━━━	━━━ △ a	━━━ ▲ b c			5, 10 (OWPO)
3. **Evaluate Artificial and Natural Wetlands For Treatment and Disposal** Outputs: a) Annual interim reports; b) Assessment of wetlands for municipal wastewater.	━━━	━━━	━━━	△ a ━━━	△ a ━━━	△ a ━━━ ▲ b	5, 10 (OWPO)
4. **Technology Transfer** Outputs: a) Numerous technical support activities.	━━━	━━━	━━━	━━━	━━━	━━━	(OWPO)
R & D Resources		485	350	875	800	850	

Agency Research Requirements, Priorities and Future Direction

Research into urban runoff control supports Agency objectives in the Section 201 Grants Program for construction of treatment works, the Section 208 Areawide Waste Management Planning Program and the Section 314 Clean Lakes Program. The research products have thus far resulted in the development and early evaluation of new and improved technology utilized in the NURP and Construction Grants Program. In addition, urban runoff control activities are a component in the support of Title III Standards and Enforcement responsibilities. Specific requirements addressed by elements of research to be conducted in urban runoff control were listed earlier in Section III; these requirements tended to concentrate in the following areas:

- The development of innovative treatment and control technology for CSOs
- The development of nonstructural and low structural options for control of urban stormwater runoff
- The development of implementation and design approaches for remedial programs
- The development and verification of user assistance tools.

Research, both planned and on-going, in these areas is directly supportive of the Construction Grant Program and NURP objectives and should further the delineation of Agency policy in this crucial area. As indicated in Section I, research planning to define receiving water impacts required for establishing water quality criteria or standards is the responsibility of the Water Quality Research Committee.

Overview of Objectives

The urban runoff research effort has three major objectives:

- Pollution Problem Assessment. Management and user assistance tools such as residuals handling methods, guidelines and user manuals for wet weather measuring and sampling, statistical methods for quality and quantity predictions and cost-effective determinations
- Stormwater Pollution Control. Work in this area is directed toward the development and evaluation of BMPs and other remedial measures for runoff control, technical assistance to NURP and lake/wetland restoration activities.
- CSO Pollution Management. Research topics here include needs survey support, dual use (wet/dry weather) facilities, infiltration and inflow controls, high rate treatment methods and applications and methods/concept for optimizing control facility design, capital cost, management flexibility and operating cost.

ORD Plans and Activities

Current activities in the urban runoff program include problem assessment, technology development for flow control and dual (wet/dry weather) treatment, development of preventive management techniques, best management practices for municipal pollution abatement and predictive and user assistance tools for implementing remedial actions. The products of this research include criteria, guidelines, manuals, and methods to assess and formulate solutions for urban sewered and unsewered wet weather pollution. Recent accomplishments include publication of "Sewer System Evaluation, Rehabilitation and New Construction - A Manual of Practices."

Table IV-6 summarizes planned research activities through 1984 showing output dates of key efforts. Again, the outputs shown relate directly to the urban runoff Laboratory Output Plan where additional detail on outputs may be found. The right-hand column of the table lists the research requirements, identified earlier in Section III, which are addressed by this research program as well as the client office supported.

Response to Stated Research Requirements

Three requirements (Nos. 3, 17, and 21) of the 25 identified in Section III are not directly addressed by the research effort. Requirement #3 (Provide technical assistance team for sewer rehabilitation problems) exceeds ORD's expectations of resources to be allocated to that activity. Requirement #17 (Develop material balance for urban runoff) would also involve a significant commitment of resources and discussions will need to be held with NURP personnel to determine the appropriateness of this effort to program goals. Impacts on receiving waters would not be part of this effort. Requirement #21 (Demonstrate microscreening with high-rate disinfection) was the subject of extensive ORD research in past years. ORD will make the pertinent reports available to the regional office.

7. MUNICIPAL WASTEWATER REUSE AND WATER CONSERVATION

The 1977 Clean Water Act Amendments provide financial incentives when innovative or alternative technology is used for construction of POTWs that incorporate reuse of effluent. The Act also requires that water conservation alternatives be evaluated. Section 208 plans must address wastewater reuse as a water quality management tool. In addition Section 1444(a)(2) of PL 93-523, the "Safe Drinking Water Act," authorizes a program to demonstrate potable reuse of wastewater. Also, Section 5 of PL 95-155, the "EPA Research and Development Authorization Act of 1978," reemphasizes Congress' interest in establishing a potable reuse demonstration program.

Agency Research Requirements, Priorities and Future Directions

The major requirements in the reuse area are to determine the long-term health effects associated with both potable and non-potable reuse. Wastewater reuse quality standards and appropriate treatment technology cannot be realistically developed without this data base. Current and future efforts are to take place in the area of evaluations of potential potable reuse systems to

Table IV-6 Urban Runoff, R & D Outputs and Resources
(Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. Pollution Problem Assessment Outputs: a) Studies of sediment impacts and benthic effects (multi-city); b) Symposium on receiving water impacts from urban stormwater; c) Nationwide assessment of receiving water impacts; d) Matrices of causes & effects of urban runoff (short-term); e) Movement & effects of CSO sediments in receiving waters; f) Longer term impact matrices.		▲a ▲b ▲a/c ▲d 240	▲e 400	▲d ▲a ▲f 250	304	375	7, 9, 10, 13, 15, 16, 18, 22, 24 (OWPO, OWPS, OSW, OWE, OPTS, Regions I, II, V)
2. Stormwater Pollution Control Outputs: a) Evaluation of eutrophic lake restoration; b) Compendium of urban wetland utilization; c) Document on remedial considerations in urban runoff pollution abatement; d) Compendium of BMPs for urban runoff pollution control; e) Demo of swirl, helical bend and teacup concentrator/regulators; f) Needs survey support; g) Section 208 (NURP) support.		▲a 340	▲b/c 650	▲d 650	▲e ▲f ▲g 900	900	2, 5, 11, 12, 13, 18, 19 (OWPO, OWPS, OWE Region I)
3. CSO Pollution Management Outputs: a) Planning & design principles for urban runoff control facilities; b) Storage/sedimentation design manual; c) Stormwater evaluation methodology and flow monitoring manual; d) Assessment of dual wet weather facilities; e) Demo of high gradient magnetic separation; f) Demo of dual use treatment; g) Demo of fluidized bed reactors (tentative); h) Develop a new technical procedure for evaluation and correction of sewer system I/I; i) Great Lakes Program cooperative projects (various outputs).		540	250	▲a/b/c 400	▲d/e 175	▲f ▲g 175	1, 4, 6, 8, 13, 19, 20, 22, 23, 25 (OWPO, OWPS, OWE, Regions I, IV, VII)

determine public health, economic, social, and institutional feasibility and, to a lesser extent, the more near-term, less research intensive, non-potable reuse of wastewater.

Comprehensive information is needed on the advantages and disadvantages of water conservation and its relative merits in economic terms so that individuals and communities can make informed decisions for their own specific situations. Particular emphasis should be placed on the impacts of water conservation on municipal wastewater collection and treatment facilities and individual systems as these impacts are related to savings in capital and operating expenditures.

Other perceived requirements include the following:

- Automated monitoring and process control for potable reuse facilities
- National follow-up of 1976-1977 California Water Conservation Impact Study to include experiences in other geographical areas
- The ability of potential users to adapt to various water qualities, e.g., the feasibility of using lower quality water for a specific industrial process
- Cost-effective trace organic removal technology
- Technical and economic analysis of dual (multiple) distribution systems, e.g., design, public health protection monitoring, control, and cost-effectiveness
- OWPS and OWPO requirements for water quality criteria pertaining to multi-purpose projects.

Wastewater reuse and water conservation is a multidisciplinary and multiorganizational program. Within EPA, in addition to the ORD program, the Offices of Drinking Water, Water Planning and Standards, Water Program Operations and Health Effects Research are involved. Other Federal agencies, principally DOI/OWRT, NSF, and DOD, also have major programs. NASA has also conducted research in this area. The various organizations maintain communication to avoid duplication of effort.

Overview of Objectives

The major goal of the program is the implementation of research and field evaluations that determine the feasibility and practicability of implementing water conservation alternatives and reusing municipal wastewaters for both potable and non-potable purposes. Objectives include a long-term evaluation of potential health effects, an evaluation of state-of-the-art technology performance, and a determination of the impacts of conservation practices on wastewater collection and treatment systems.

ORD Plans and Activities

As seen in Table IV-7, the ORD MERL program is currently concentrating its resources upon implementing evaluations of potential potable reuse systems. In future years research on technology for reuse applications will be included as part of the Process Development activity and will continue to include water conservation.

Response to Stated Research Requirements

ORD is undertaking a major program to evaluate the performance and reliability of advanced technology for producing a potable quality water for reuse but until standards for potable reuse are established, progress will be limited. Only selective and limited research efforts in non-potable reuse have been indicated in an attempt to avoid duplication in work carried out by other agencies, principally the Department Of Interior (Office of Water Research and Technology, OWRT). Further, since water conservation is presently in a transitional state, a coordinated research effort and the necessary support funding are prerequisites to meeting research requirements in this area.

More specifically, of the eight identified research requirements, two (Nos. 6 and 8) do not appear to be addressed. Requirement #6 (Minimize impact on biota of reuse for cooling) is a more proper subject for the Industrial Wastewater Research Committee to address. Requirement #8 (Use of salt water for toilets and groundwater protection) is to be explored further with Region IX before committing ORD resources.

8. SMALL WASTEWATER FLOWS

This research area supports Agency efforts to encourage and provide construction grants for cost-effective management of small wastewater flows (SWF) and alternative collection systems and septage management from one or more residences and/or commercial units. The Clean Water Act Amendments (PL 95-217) in Section 201 authorize Federal funds for individual systems where more cost-effective than conventional treatment systems or provided that the cost is within 15% of the least cost, centralized treatment system. Section 201 encourages innovative and alternative technology as it applies to SWF management.

Agency Research Requirements, Priorities and Future Directions

Prior to 1978, the SWF research effort focused on evaluating I&A technologies in order to assess their performance, design parameters and costs. Because PL 95-217 specifically requires the evaluation of I&A technologies and provides construction grants for cost-effective SWF systems, the SWF program has grown to support the construction grants program through major technical assistance efforts in promoting the speedy and intelligent application of small flows technology. The Section 208 Planning Program in OWPS also receives significant support from the research effort. While specific research requirements were identified earlier, the overall need is for practical handbooks, manuals and reports for use by regulatory agencies, consulting engineers and others. These documents should provide specific details on the design, operations, applicability, costs and environmental implications of alternatives available for collection, treatment and disposal of small wastewater flows.

Table IV-7 Municipal Wastewater Reuse and Water Conservation, R & D Outputs and Resources (Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. **Denver Potable Water Reuse Demonstration** Outputs: a) Completed design; b) Construction complete; c) Trial operation completed.			a		b	c	2, 4 (OWPO) *
2. **Potable Reuse Demonstration at Existing Sites** Outputs: a) Final reports on facilities having different geographic, climatic and institutional characteristics and treatment processes.						a	2, 4, 7 (OWPO, Region IX) *
3. **Water Conservation Practices Impact on Wastewater Collection and Treatment Systems** Outputs: a) California report; b) East and midwest reports; c) Guidelines.		a			b	c	3, 5, 7 (OWPO, Regions I, IX)
4. **Non-Potable Reuse Criteria and System Evaluations** Outputs: a) Reuse guidelines; b) dual distribution users manual; c) System evaluation reports; d) Water quality criteria report.		a			b	c d	1, 4 (OWPO)
R & D Resources		1224	980	831	214	215	

* Because of the legislative directives mandating research into potable reuse, the U.S. Congress should be considered the principal client for this work.

Overview of Objectives

The SWF program has two major objectives, as follows:

- Characterize technical, cost, performance and reliability aspects of systems to serve small communities, including recreational areas.
- Develop and evaluate alternative technology for individual homes and small communities taking into account public health environmental and energy and water conservation consideration.

ORD Plans and Activities

ORD's planned research outputs are indicated in Table IV-8. Interim and periodic reports are shown as hollow triangles while final outputs are depicted as solid triangles. As is apparent from the chart SWF research emphasizes useful outputs such as manuals and handbooks.

The Committee members feel that an additional objective should be added to those described above with a concomitant increase in funding, to address two areas of increasing concern. The new initiative would be to develop a Center for Small Community wastewater Systems Studies, and to increase the role of the National Clearinghouse to more active one by transferring responsibility for its operation from CERI to MERL. The proposed Center for SWF would be designed to provide more direct field experience, cost and performance data for several on-site and cluster wastewater systems. Such a Center would be designed for flexible operations so as to permit incorporation of additional technologies as they become available for field test and evaluation. It would not be a centralized facility, as is the existing T&E facility, but would function in a defined geographical area in a dispersed mode and under a centralized management. This upgrading of program would require an additional $525 K in 1982 and two positions for effective research capability.

Response to Stated Research Requirements

Five of the fifteen research requirements identified in Section III are not explicitly addressed under the existing research efforts (Nos. 3, 7a, 11, 12, and 15). Requirement #3 (Design and operating procedures to protect groundwater) is presently under discussion in ORD as to the proper scope of the needed research effort since the problem extends to sludge and wastewater application to land as well. Requirement #11 (Control of acid/lime sidestream from septage treatment) is being taken up by Cincinnati laboratory personnel with Region I. Acid/lime treatment was found not to be the most feasible method for treatment in a study done for EPA by the University of Lowell. Alum is now more commonly used. Requirements #12 (Effects on wetland productivity; other options) will be subject to discussion with the Water Quality Research Committee due to its responsibility for guiding ecological effects research.

Table IV-8 Small Wastewater Flows, R & D Outputs and Resources
(Resources by FY in $000s)

R & D SUBOBJECTIVE	FY-1979 O D F A J A	FY-1980 O D F A J A	FY-1981 O D F A J A	FY-1982 O D F A J A	FY-1983 O D F A J A	FY-1984 O D F A J A	R & D REQUIREMENT ADDRESSED
1. Systems Management for Small Communities Outputs: a) Characterization of existing water quality mgmt. districts; b) Interim reports on most promising techniques for wastewater treatment, disposal and recycle for problem sources; c) Describe the design, operation/maintenance, costs and applicability for septage handling, treatment and disposal options; d) Interim report on pumpout treatment; e) Comprehensive manual synthesizing data on applicability, design O&M, and costs of pressure and vacuum sewer systems; f) Reports on "piggyback" demo. projects; g) Manual on optimum community-wide mgmt. strategies; h) Report on seasonal home systems; i) Handbook on optimized systems for small communities, design, O & M cost, and applicability data (6/85)			▲ a ▲ b c	▲ d	▲ c ▲ g ▲ e	▲ c f ▲ c h g ▲ i	1, 2, 5, 6, 7a* 8, 10, 13 (OWPO, (Regions I, II, IX)
R & D Resources		265	280	350	415	425	
2. Alternative Technology for Small Systems Outputs: a) Baseline report on wastewater generation, building technology, energy systems and other utility systems; b) Public health and environmental implications; c) Comprehensive manual on most promising systems and cost-effective remedial measures; d) Report on ways to integrate home systems to conserve energy and water and to reuse water.			▲ a		▲ b ▲ c	▲ d	1, 2, 4, 5, 6, 7, 9, 14 (OWPO, Regions I, V)
R & D Resources		590	570	725	525	525	

*Work funded by SWF research effort but being carried out under Toxic Pollutants Control contract.

9. INNOVATIVE AND ALTERNATIVE TECHNOLOGY

Greater use of systems that reclaim and reuse wastewater, productively recycle wastewater constituents, and otherwise eliminate the discharge of pollutants or recover energy is the Congressional intent of meeting the Nation's water quality goals. To carry out the mandates of the Clean Water Act, the Innovative and Alternative (I/A) Technical Support Group at MERL was established to assist in the administration of the innovative and alternative requirements of the Construction Grants Program. The criteria for qualifying for an innovative and alternative construction grant include the savings of life cycle costs and energy which are tangible, and the improvements of operational reliability, toxics management, environmental benefit, and industrial-municipal joint treatment potential, which are mostly intangible and difficult to express in monetary terms.

Agency Research Requirements, Priorities, and Future Directions

The perceived research requirements beyond those stated in Section III are for ORD to provide the information needed to encourage I/A construction nationwide, provide guidance and support to state and regional offices in evaluating I/A applications, measure progress, and evaluate results. In addition, detailed evaluations of I&A projects as authorized under Sec. 105(j) will be needed as the implementation of these technologies is stepped up. The primary focus now and for the foreseeable future, in the absence of new resources, is the provision of a large amount of research staff technical assistance to the Construction Grants Program.

ORD proposes to expand the existing I&A research effort to enable these substantive requirements to be met through reprogramming of funds as appropriate in 1981 and hopefully through the adoption of a new initiative, described in the following section, starting in 1982. Such an approach is required if I&A technologies are to make the dramatic contribution to water improvement envisioned by the 1977 Amendments. Development of new or improved technologies which can be incorporated into the Agency I/A Program is carried out as part of the Process Development activity.

Overview of Objectives

Major goals of the research program are to support the national program and to encourage the use of technologies that reclaim and recycle water and nutrients, lower total project costs, and conserve or recover energy. Additional goals will be met by monitoring the use of I&A technologies nationwide and through evaluating the performance and costs of I&A systems under grants authorized by Sec. 105(j) of PL 95-217.

ORD Plans and Activities

ORD planned outputs are presented in Table IV-9 for the current legislated lifetime of the I&A program. R&D requirements addressed and the client offices served are shown in the right-hand column. Interim or annual reports are indicated on the chart as hollow triangles while final outputs are shown as solid triangles. A more detailed description of the research outputs is provided in the Laboratory Output Plan.

Table IV-9 Innovative and Alternative Technology, R & D Outputs and Resources
(Resources in Fiscal Year in $000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. **I & A Technology Evaluation Program Support** Outputs: a) Annual management effec-A Tech. assessment manual; c) Studies of effectiveness in meeting national goals d) I & A programs and trend reports; e) Annual clearinghouse summary report (quarterly reports not shown)	△ a	▲ b △ a	▲ c d e △ a	▲ c e	▲ c e		1, 2, 3, 8 (OWPO, Region I)
R & D Resources		755	828	760	505	505	

Beyond the specific planned activities, the Research Committee has concluded that additional research efforts need to be undertaken in order to fulfill the objectives of the legislative mandate. The initial five-man commitment only permitted the marginal operation of a passive-reactive program that did not actively promote innovative technology but only judges that proposed by others. This does not take advantage of ORD's technology development efforts over the past ten years. A more aggressive and intensive effort is necessary to carry out an active program; therefore, an additional three staff years have been committed to the effort and the Committee proposes that a new initiative be incorporated into the I&A research effort to enable the evaluation of I&A technologies, as discussed below.

I&A provisions in the Clean Water Act call for the post-construction evaluation of I&A projects by ORD under Section 105(j) to determine whether to encourage their greater utilization. This initiative would enable the detailed evaluation of numerous projects designated as "innovative" technology as well as projects utilizing "alternative" technology starting in 1982 at a graduated funding level of about $2 million per year in 1982, $4 million in 1983 and $8 million in 1984. Two additional research positions are required in each of the three years.

Response to Stated Research Requirements

Of the ten research requirements specified in Section III, six (Nos. 4, 5, 6, 7, 9, and 10) are not addressed within the current research plan. Requirement #4 (Detailed evaluation of Sec. 105(j) projects; cost, performance and reliability data for I&A) would be addressed by the first of the two proposed initiatives if funds become available. Requirement #5 (Performance of I&A technologies on toxics) attempts to insure that the need for toxic pollutant control is not overlooked in the push to emplace I&A technologies. The effectiveness of I&A technologies in controlling toxics may become one of the technical performance characteristics measured in the evaluations contemplated under the Sec. 105(j) initiative. Requirement #6 (Methods to reduce energy consumption at POTWs) is addressed by a new initiative proposed under Plant Operation and Design.

Requirement #7 (Criteria for justification of 100% replacement) is of recognized importance with OWPO ultimately responsible. An approach to this problem is being formulated by OWPO with the assistance of ORD.

Requirement #9 (Demo of vertical tube reactor system) is difficult for ORD to address due to the lack of a recognized technology demonstration program. Vertical tube reactor systems are currently under development at pilot scale and could be included in the innovative technology evaluations proposed above or incorporated into a construction grant project.

Requirement #10 (Demo of wet oxidation of sludges) although requested under I&A is actually addressed under the Municipal Sludge Management - Conversion and Energy Recovery research effort. Outputs were described earlier in Table IV-3b.

10. HEALTH EFFECTS RESEARCH

ORD's health effects research responds to requirements of the Clean Water Act calling for the safe treatment, disposal and possible reuse of municipal wastewater and sludge and for the development of a health effects data base for setting water quality standards and effluent guidelines.

Agency Research Requirements, Priorities and Future Directions

The health effects research activities of importance to the Municipal Wastewater Ocean Disposal and Spill Prevention Research Committee, as is discussed further below, support operating program needs in three areas: wastewater and sludge management, reuse and recycling of wastewater, and urban runoff. Program requirements in the first area center on the need to understand the health effects associated with innovative technologies for wastewater and sludge management. Of major concern are the concentrations of microorganisms, organics, pesticides, cadmium, lead and other metals in municipal sludge and the possible effects on human health from various routes of exposure.

R&D Activities in the area of reuse and recycling of wastewater relate to a perceived future requirement to make the most efficient use of water resources and treatment capacity by facilitating industrial, agricultural and possibly potable reuse of treated wastewater. These objectives similarly support the elimination of pollutant discharges and the preparation of guidelines for aquaculture (Section 318 of CWA Amendments).

In the urban runoff area, there is a need to better understand and relate the treatment of point and non-point source discharges to health effects. Evaluation of the need for advanced wastewater treatment to obtain a relatively safe effluent to prevent health effects in recreational waters is necessary, as well as better indicators of microbiological treatment efficiency.

Overview of Objectives

The major objective of the health effects research program is the establishment of needed health effects data bases in four key areas, namely:

- Wastewater and Sludge Management. The objective here is to determine the health implications of existing and innovative technology for the treatment and disposal of wastewater and sludge.
- Toxics in Water. The primary objective here is to develop rapid screening tests for characterizing toxic pollutants in complex effluents and determine their importance to human health.
- Reuse and Recycling of Wastewater. This area's objective is to develop criteria for the safe reuse of

wastewater for industrial, agricultural and potentially potable purposes and to assess the possible health impacts associated with reuse of renovated wastewater.

- Urban Runoff. The health effects objectives in this area are to determine the potential impact on human health of combined sewer overflows and stormwater discharges.

Not all of the four research areas listed above fall completely within the purview of the Municipal Wastewater Ocean Disposal and Spill Prevention Research Committee. Research on toxic substances identified in the NRDC Consent Decree and on the development of bioassay methods for detecting toxic substances in waters receiving complex effluents are also of interest to the Water Quality Research Committee and the Committee on Toxic Testing and Assessment. Respective roles need to be clarified. The development of freshwater recreational water quality criteria fall under the jurisdiction of the Water Quality Research Committee while the impact of the degree of treatment is the purview of the Municipal Wastewater Committee.

Likewise, research into potential health hazards related to the use of treated wastewater for industrial purposes is subject to review by the Industrial Wastewater Research Committee. Accordingly, this document will focus on health effects research being conducted in the areas of Wastewater and Sludge Management, the Reuse and Recycling of Wastewater, and Urban Runoff and Wastewater Treatment.

The current program in health effects supports the broad objectives identified above in several ways as discussed in the sections below.

Wastewater and Sludge Management

The Health Effects Research Laboratory (HERL) in Cincinnati has been requested to conduct health assessments related to the safe treatment and disposal of municipal wastewater and sludge. Specific subobjectives in support of this goal are:

- Measure and evaluate the pathogen and chemical contamination hazards associated with land application of wastewater and sludge.

- Support studies on possible transmission of contaminants, including cadmium, microbiological agents, and persistent organics, through the food chain.

- Perform epidemiological studies on populations with exposure to wastewater and sludge, including microbial aerosols.

- Expand the data base on health risks of other forms of sludge disposal, including incineration and composting.

Reuse and Recycling of Wastewater

As noted earlier, the primary objective of this effort is to develop criteria for the safe reuse of wastewater for industrial, agricultural and possibly potable purposes. In addition, HERL will work with other laboratories in developing the health aspects of criteria for non-potable reuse. In support of this objective are the following subobjectives and activities:

- Establish for the users of renovated wastewater health effects criteria which can be extrapolated to effluent guidelines. Activities to be carried out in this area involve the appraisal of the potential health hazards associated with reusing treated wastewater for potable and non-potable purposes by determining:
    - Whether there are potentially carcinogenic organic constituents in effluents from advanced waste treatment systems
    - Whether the type of treatment system affects the nature and toxicity of the organic substances
    - Toxicity testing procedures which may be applied to reuse situations
    - Health risks of viruses occurring in the effluents
    - Whether groundwater aquifers recharged with treated effluents have a health impact on man.
    - The health implications of non-potable reuse.
- Appraise the potential health hazards related to using treated wastewater in commercial aquaculture. Data base development is currently proceeding.

Urban Runoff and Wastewater Treatment

Runoff from non-point sources and discharges from point sources could potentially result in health effects for users of receiving waters. Even after conventional treatment, residual contaminants could increase the risk of using the waters. The following subobjectives address the issues:

- Determine the relationship between contaminants remaining after secondary and advanced wastewater treatment and illness rates for users of the receiving waters.
- Develop a better indicator of pathogenesis potential of wastewaters, especially of viruses.
- Develop health related criteria for stormwater discharges.

ORD Plans and Activities

Table IV-10 summarizes planned research through 1984, indicating dates for key outputs described in the Laboratory Output Plan (LOP). The corresponding R&D needs addressed are shown in the right-hand column, keyed to the various technology research areas supported as shown in the legend at the base of the chart. In order to respond to several Program Office concerns the Committee proposes a new initiative focusing on health effects associated with small wastewater flow (SWF) systems, aquacultural by-products and the impact of urban runoff on users of receiving waters. The orientation toward SWF health effects reflects the virtual absence of information in this area. The emphasis on aquaculture, on the other hand, arises from a recognition that, although we are able to utilize nutrients in aquaculture systems, we must ensure that the products themselves do not create public health problems.

The third area covered under the proposed initiative recognizes that runoff from non-point sources and discharges from point sources could potentially result in health effects for users of receiving waters. Even after conventional treatment, residual contaminants could increase the risk of using the waters. The following subobjectives address the issues:

- o Determine the relationship between contaminants remaining after secondary and advanced wastewater treatment and illness rate of users of the receiving waters.
- o Develop a better indicator of pathogenesis potential of wastewaters, especially of viruses.
- o Develop health related criteria for stormwater discharges.

The initiative is estimated to cost about $600 K per year and no new positions.

Response to Stated Research Requirements

In general no major gaps in the research program have been identified. However, of the twenty-five health effects research requirements, seven (SM-2, SM-3, SM-9, LA-6, LA-11, SF-1, and SF-2) are not explicitly addressed within the existing research effort. These requirements and ORD's response are discussed here.

Requirement SM-2 (Health risk of lead to small children and pregnant women) and SM-3 (Assessment of PCBs in dairy products, beef fat) are in the process of being more explicitly stated by OSW.

Requirements SM-9 and LA-11 (Safety of foodstuffs grown under land application of sludge and wastewater, respectively) have been the subject of previous ORD research efforts. Discussions are to be carried out with Region IX to determine the applicability of the research results.

Table IV-10 Health Effects, R & D Outputs and Resources
(Resources by FY in '000s)

R & D SUBOBJECTIVE	FY-1979	FY-1980	FY-1981	FY-1982	FY-1983	FY-1984	R & D REQUIREMENT ADDRESSED
	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	O D F A J A	
1. Land Application of Sludge and Treated Wastewater Outputs: a) Appraisal of irrigation of agricultural land using treated wastewater; b) Appraisal of fate of viruses; c) Levels of cadmium-exposure indicators in U.S.; d) Sludge effects via animal pathways; e) Appraisal of processing and land application of municipal sludge; f) Technology for microbial measurements of aerosols; g) Appraisal of animal viruses in soil water systems; h) Occurrence, cross-transmission and infectivity of parasites in sludge; i) Pathogen hazard to farm families.	—	△ a	▲ b c d	▲ e f g h	▲ i	▲ a	TC-1, SM-1, SM-4, SM-5, SM-7, SM-8, LA-1, LA-2, LA-3, LA-4, LA-5, LA-10 (OWPO, OSW, Regions VI, VIII)
R & D Resources		2,200	1,999	1,899	2,200	2,600	
2. Health Effects Associated with Domestic Water Reuse Outputs: a) Evaluation of organics in wastewater processed for reuse; b) Criteria for use of renovated wastewater for potable purposes; c) Rapid toxicity testing procedures using mammalian cells; d) Data base on virus spectrum in AWT plants; e) Aquaculture; f) Mutagenic/carcinogenic potential of organic substances in renovated waters.	—	—	△ a	▲ b	▲ c d	▲ a e f	LA-5, LA-7, LA-8, LA-9, CR-1 (Regions V, VI, VIII)
R & D Resources		600	700	700	700	700	
3. Appraisal of Health Effects of Other Sludge Treatment, Disposal and Utilization Practices Outputs: a) Composting processes; b) Epidemiological studies near sludge incineration and drying processes.	—	△ a	—	—	▲ a	▲ b	SM-6 (Region II)
R & D Resources		580	600	600	900	300	
4. Urban Runoff and Wastewater Treatment **Outputs: a) Improved indicator of treatment efficiencies and/or potential health studies; b) Epidemiological studies relating illness to degree of treatment; c) Develop microbial treatment criteria for stormwaters; d) Assessment of toxic and carcinogenic potential of urban runoff and CSOs.**		—	—	—	—	▲ a b ▲ c d	9, 10, 11, 14, 16, 24, 25 (OWPS, Regions II, IV)*
		100	100	200	200	200	

Key for R & D Needs:

SM:	Municipal Sludge Management
CR:	Conservation and Reuse
LA:	Land Application of Wastewater and Aquaculture
TC:	Toxic Pollutants Control

*Health effects components of urban runoff research requirements identified in Tables III-1 through III-10.

Requirement LA-6 (Need for disinfection prior to land application) is a current topic of discussion at RSKERL. The planned ORD budget does not address this important area explicitly but current and planned HERL epidemiological studies will provide important information on the issue.

Requirements SF-1 (Health impacts of small wastewater flow systems) and SF-2 (Evaluation of various SWF systems) need greater specificity before appropriate ORD action can be taken. Should septic tanks, and home treatment systems, for example, be addressed? Future editions of the strategy document will address these requirements.

11. MONITORING SYSTEMS AND QUALITY ASSURANCE RESEARCH

ORD's monitoring research responds to the requirements of the Regions and Program Offices for the application of overhead monitoring systems to answer short-term problems and for monitoring water quality standards. ORD proposes to continue the existing efforts at the present level of effort. Technical support is provided on a continuing basis as and when required by operating programs and regions.

APPENDIX A

PERSPECTIVES OF OTHER AGENCIES AND ORGANIZATIONS ON EPA R&D REQUIREMENTS AND ACTIVITIES

PERSPECTIVES OF OTHER AGENCIES AND ORGANIZATIONS ON EPA R&D REQUIREMENTS AND ACTIVITIES

THE MILITARY

Major groups concerned with wastewater research are:

1. Army
   - Civil Engineering Research Laboratory (CERL), Champaign, Illinois
   - Corps of Engineers (COE) Water Pollution Abatement Program (WPA) Office, Huntsville, Alabama
   - The COE Cold Regions Research Laboratory in New Hampshire
   - The COE Waterways Experiment Station in Vicksburg, Mississippi
   - Army Medical Research Group, Fort Dietrich, Maryland
   - Army Hazardous Material Laboratory, Aberdeen, Maryland
2. Navy
   - Navy Engineering Research Laboratory (NERL), Pt. Hueneme, California
3. Air Force
   - Air Force Environmental Engineering Laboratory, Tyndall AFB, Florida

The above-named entities within DOD are interested in EPA's wastewater research strategy, and expressed interest in reviewing the draft document. In general, they look to EPA for much of their basic information in providing guidance to their "clients," e.g., the military operating offices and individual bases. Their goals are as follows:

- Bring all military installations in conformance with federal, state, and local environmental regulations, both existing and proposed.
- Characterize and quantify wastewater emissions from military activities with emphasis upon wastes unique to the military, e.g., shell casing cleaning, jet engine testing, etc.
- Conduct research into the analysis, monitoring, treatability, recycle/reuse, etc. of military wastewaters, again with emphasis upon wastes unique to the military.

- Provide guidance to base personnel, design engineers, regulatory agencies, etc., in the implementation of cost-effective wastewater treatment and sludge management. Guidance is in the form of manuals, directives, plan review, etc.

In summary, the military has a limited wastewater research budget. They attempt to make maximum use of published EPA research information in the implementation of their wastewater planning. Their perceived research needs are as follows:

- Identification and quantification of toxic/hazardous constituents in military wastewaters. At present, except for the Aberdeen group, they have little information about the presence of priority pollutants in their wastewaters.
- Treatability of military wastewaters to remove priority pollutants in the most cost-effective manner from both combined domestic/industrial interested in unit treatment processes, treatment systems, and land treatment alternatives. Work carried out under the purview of the Industrial Wastewater R&D Strategy would be of interest here also.
- Management of residuals, e.g., sludge, from wastewater treatment.
- Development of inexpensive analysis and monitoring methods for critical constituents in military wastewaters. They are hopeful that EPA research will identify surrogate chemicals so that they will not be faced with monitoring a wide spectrum of organic and inorganic pollutants.
- Because most of its bases are located on the coast, the Navy is particularly interested in marine discharge of priority pollutants. Is there a need for control when the receiving water is not potable?
- Because most of their bases contain large land areas, the Army and Air Force are particularly interested in land treatment of wastes containing priority pollutants. What is the impact of landspreading, rapid infiltration, or overland flow in mitigating the potential environmental effects?
- There is a substantial interest in wastewater recycle/reuse for both non-potable and potable purposes.

HOUSING AND URBAN DEVELOPMENT (HUD)

HUD is interested in EPA research which will ease the development of new housing through solution of wastewater management problems. Its perceived research needs are as follows:

- Small flows management with emphasis upon rapid information transfer of new technology developments to the local level where builders and regulatory agencies operate. Specific areas include:

  - design of on-site systems, e.g., septic tanks, individual home biological units, etc., including use of such units for clusters of dwelling units.

  - management programs for maintenance of on-site systems, e.g., public septic tank maintenance districts, etc.

  - in-house water conservation and water reuse, tied into building code modifications and, where possible, energy conservation.

- Increased acceptance and reliability of alternate collection systems, e.g., pressure sewer and vacuum sewer systems.

- Elimination of inadequacies in POTW's which result in building moratoriums. HUD is interested in research which leads to increased capacity and reliability of existing POTW's, e.g., flow equalization, upstream retention, chemical treatment enhancement, improved O&M, etc. HUD is also interested in means for speeding up new POTW construction through streamlining of the construction grant, permit, review, etc., process.

U.S. GEOLOGICAL SURVEY (USGS)

USGS's primary interest in EPA wastewater research is in the tying together of EPA activities and USGS activities pertinent to systematizing the interrelationships between stream flows, water quality, and wastewater discharges. USGS perceives no need for EPA research per se to satisfy its own objectives, but sees itself as providing important input to EPA research efforts in such areas as:

- Development of wasteload allocations in receiving waters.

- Eventual development of a surface water data management system which ties together all wastewater discharges (by location, quantity, and quality), receiving water identification by a nationally indexed system for each reach of river, stream, etc., surface water flow and quality of each reach, and effect of present and proposed discharges upon each surface waste's reach.

- A similar system for non-point source data management.

Research of the character indicated above does not influence directly the nature of R&D discussed in this document. Rather, these research areas fall under the purview of the Water Quality Research Committee.

U.S. DEPARTMENT OF AGRICULTURE (USDA)

USDA is interested in research into wastewater and sludge land treatment as it may affect food crops and/or livestock which are affected presently or in the future by contact with the waste-amended soil. It perceives the following research needs in municipal wastewater.

- Long-term effects upon soil which receives municipal wastewater or sludges, in terms of suitability for various crops, productivity, and physical and chemical changes. Also interested in mitigating management practices.
- Uptake by various edible crops of toxics harmful to human health.
- Bio-concentration of toxics in livestock which feed upon crops grown in soil amended with wastewater or sludge.
- Potential health effects upon agricultural workers from bacteria, viruses, parasites, etc.
- Changes in irrigation and fertilization practices necessary when using wastewater or sludges vs. use of freshwater and commercial fertilizers.

EPA has several cooperative efforts with USDA in nonpoint source control, e.g., USDA's controlled watersheds and small watersheds programs. In addition, EPA is conducting cooperative investigations with USDA in the pesticide area. Finally, USDA is beginning an internal aquaculture program which will reportedly cooperate closely with related EPA programs. The Department also cooperated with EPA and the U.S. Army Corps of Engineers in preparing and distributing the "Process Design Manual for Land Treatment of Municipal Wastewater". In addition, EPA is conducting cooperative investigations with USDA in the pesticide area and also in a study of metals in soils and food crops in the U.S.

U.S. FOOD AND DRUG ADMINISTRATION (FDA)

The EPA coordinates its research efforts in several areas with FDA, including shellfish pollution studies and studies of crop uptake of pollutants from wastewater or sludge-amended soils. A control study is looking at similar uptakes from commercial fertilizer application. Perceived research needs by FDA include:

- Continued investigation of plant uptake of wastewater and/or sludge contaminants.
- Investigation of livestock bio-concentration of these contaminants (particularly in liver, kidney, and other vital organs) when fed fodder grown in wastewater or sludge-amended soils.
- Continued investigation of shellfish contamination from municipal wastewater.

While not noted as a need by FDA, consideration might be given to transfer of information in the priority pollutant area. Many canned and preserved foods and beverages contain water added in processing. As EPA learns more about the prevalence, toxicity, etc., of these pollutants in water supplies, this information should be used by FDA. As in the case of the USDA, FDA research requirements are more properly the responsibility of the Water Quality Research Committee.

WATER POLLUTION CONTROL FEDERATION (WPCF)

The WPCF believes that the EPA R&D program should be a major, far-reaching effort with both short- and long-term goals. It should be anticipatory, as well as responsive, to immediate research needs. A balanced program is needed which gives appropriate weight to basic research as well as studies of a more developmental nature.

The WPCF believes that the EPA R&D budget is much too small in comparison to the requirements and goals of environmental legislation, and relative to the massive construction grants expenditures.

Specifically, WPCF places highest priority on the subjects of sludge handling and disposal and toxic substances. Other subjects of high priority are as follows:

- Emphasis upon STP O&M, including definition of the causes for poor operational performance of existing STP's, analysis of these causes, and development of corrective strategies.
- Pollution from nonpoint sources.
- Ecological and health effects of pollutants.

THE AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

The major source identifying research requirements perceived by ASCE is a document developed by an NSF-ASCE study group in early 1979. The following is a summary of the group's findings.

1. Toxic Substances

The study team suggests these research objectives:

- Improve current screening tests for near-term determination of probable threshold toxicity levels.
- Determine relationships between presence of toxic substances and the health records of those exposed, so as to establish some reliable threshold toxicity levels.
- Investigate potential for the bio-concentration of toxic substances, their mode of transfer and transport in the environment, and the probability that these may cause toxicity through the food chain of man.

- Establish "acceptable" risk concentration levels of toxic substances in the environment.

- Develop control technologies as needed to achieve "acceptable" risk concentration levels.

2. Nonpoint Sources of Pollution

The following research objectives on nonpoint sources are suggested:

- Develop management strategies for application of fertilizer and pesticides on agricultural and urban land to minimize runoff of nutrients and toxic materials.

- Define the potential health effects of urban stormwater discharges on drinking water supply.

- Determine the impact of pollutants found in urban runoff on receiving water biota.

- Establish the relationships between air quality and urban runoff quality.

- Establish the principles of transport and the disposition in water of land-eroded suspended matter.

- Define the alternatives and establish cooperative costs/benefits for non-structural and/or structural controls of urban runoff versus collection and treatment.

3. Land Treatment of Wastewater and Sludge Disposal

- Research is proposed to evaluate the risk to society of land treatment, including impacts on groundwater, air quality (aerosols), soil and food chains.

4. Pollution Concentration and Toxicity Measurements

Research needs identified are:

- Develop simpler analytical techniques.

- Develop remote sensing techniques.

- Develop ways to assess environmental burden on the groups of sensitive species.

- Expand use of microorganisms as pollution-danger indicators.

- Develop personal monitors for determining body exposure similar to the radiation badge.

- Monitor natural, managed, and damaged ecosystems.
- Organize monitoring of tissue to detect subtle increases in burden.
- Create a natural environmental specimen bank.
- Maintain easily accessible data banks.

THE COUNCIL ON ENVIRONMENTAL QUALITY (CEQ)

CEQ places major emphasis upon control of toxic pollutants, preservation of water resources and pollution control in balance with economic costs. The Council's interest in EPA water pollution programs focuses around the Construction Grants Program and, in particular, on the implementation of the Innovative and Alternative (I&A) Technology effort initiated by EPA. The Council has a high level of interest in the Construction Grants Program and in implementing the "Innovative and Alternative" technology sections of the Clean Water Act.

DEPARTMENT OF INTERIOR/OFFICE OF WATER RESEARCH AND TECHNOLOGY (DOI/OWRT)

OWRT conducts a broad-based water resources research program focusing primarily upon the following topics:

- Water Reuse. Emphasis here is on industrial reuse and irrigation using recycled wastewater. Potable reuse is not considered a major end use for renovated wastewater due to high costs and the potential risks to public health.
- Water Conservation. Potential for water conservation is large and several projects are under way to demonstrate its applicability.
- Water Problems of Urban Areas. While no organized stormwater control program has been established, several university research programs, funded by OWRT, are addressing the problem in specific locales.
- Saline Water Conversion Technology. Reverse osmosis, electrodialysis and other advanced processes are under development. Funds for 5 desalting demonstrations have been authorized (but not appropriated). OWRT also provides support for California's Water Factory 21.

OWRT is currently participating with both EPA and DOE in a project to clean up textile dyeing wastes for reuse and also rents a mobile treatment unit to EPA for use at industrial sites. OWRT and EPA also jointly sponsored a wastewater reuse seminar in the Spring of 1979. In addition ORD regularly assists OWRT in the annual review of grant application submitted in the wastewater reuse area thus facilitating technical interchanges between the two organizations and insuring that duplication of research efforts is avoided.

APPENDIX B

MUNICIPAL WASTEWATER R&D REQUIREMENTS BY TECHNOLOGICAL AREA

(Client Office, Priority)

MUNICIPAL WASTEWATER R&D REQUIREMENTS BY TECHNOLOGICAL AREA

(Client Office, Priority)

WASTEWATER PROCESS DEVELOPMENT

1. Energy reduction techniques for high energy phases of treatment processes. (OWPO, High)

2. Reduce energy in nontreatment components. (OWPO, High)

3. Alternative disinfectants - process implementation (costs, energy effectiveness). (OWPO, OWPS, High)

4. New treatment processes for toxic pollutant control. (OWPS, High)

5. Field investigation of actual "phostrip" (Union Carbide) installations to refine/verify manufacturer's suggested design criteria/performance levels. (Region I, High)

6. Research on high-energy electron irradiation of wastewater/sludge to refine design criteria, costs, performance and hazardous by-product formation. (Region I, High)

7. Investigate nitrate content of groundwater and develop methods to correct nitrate accumulation in deep sands of Florida Coast. (Region IV, High)

8. Comparison of chlorine versus alternative disinfectants for various types of effluents. By-product (toxic) contamination by new (alternative) disinfectant methods. (Regions V, X, High)

9. Identification of suitable criteria for determining whether disinfection should be required for a given effluent. (Region V, Medium)

10. Investigate new processes for potential toxic substances contamination by formation of toxic by-products. (Region V, Medium; Region X, High)

11. Evaluation of biodisc and ABF is necessary to confirm the design criteria for use by consulting engineers and regulatory agencies. (Region VII, High)

12. Provide complete evaluation of the deleterious effects that residual chlorine has on streams and develop design criteria for chlorination facilities that will reduce fecal coliform to adequately low concentrations. (Region VIII, High)

13. Method projecting decay of residual Cl_2 from WWTP and in receiving stream (e.g., predict decay/persistance rate from 1-2 ppm down to 0.01 ppm). (Regions VIII, X, High)

TOXIC POLLUTANTS CONTROL

1. Identification and quantification of priority pollutant sources. (OWPO, OPTS, High)

2. Design criteria and operating procedures for maintaining groundwater quality re: toxics (metals & organics) from land treatment, effluent and sludge, aquaculture and SWF systems. (OWPO, High)

3. Treatability studies on existing in-plant processes for toxics removal (cost, energy, fate). (OWPO, OPTS, Medium; OWPS, High)

4. Improved fixing of toxics in sludge. (OWPO, Medium)

5. Transport, retention studies for selected toxics (metals & organics) in land treatment, aquaculture and SWF systems (including plant uptake studies). (OWPO, Medium)

6. Screening toxics in individual home treatment systems. (OWPO, Medium)

7. New technology for toxics control with emphasis on practicality & cost.

8. Technology transfer function. (OWPO, Low)

9. From treatability data establish pretreatment credits for municipal systems (OWPS, High)

10. Develop protocols for sampling and testing. (OWPS, OPTS, High)

11. Develop test indicators and measurement methods. (OWPS, High)

12. Determine sources of priority pollutants: residential, commercial, industrial components. (OWPS, High)

13.* Determine effects of POTW discharges on biological integrity of receiving waters. (OWPS, High)

14. Perform materials balance on toxics in POTW's including air transfer (air stripping from aeration tanks). OWPS wants to extend ORD cost optimization model to simulate the toxic load of specific industries using residential and commercial source data and plant influent data. Goal is to determine toxic content of sludges under proposed BAT options. (OWPS, High; OPTS, Medium)

15.* Apply treatability research to pretreatment and combined treatment problems and determine BAT impact on receiving stream. (OWPS, Medium)

16. Evaluate efficacy of BMP's in controlling toxic pollutants. (OWPS, Medium)

17. Identify sources of other (non-priority) toxic pollutants. (OWPS, Medium)

18. Compare efficacy of secondary treatment at POTW's with source control for toxic pollutants removal. (OWPS, Medium)

19.* Determine fate of toxics from POTW's in receiving waters in cooperation with other offices. (OWPS, Medium)

20. Quantify non-point sources of toxic pollutants, make intensive study of effects and evaluate control options. (OWPS, Low; OPTS, Medium)

21. Analyze institutional impediments to pretreatment. (OWPS, Low)

22.* Compare impacts of point vs. non-point sources of toxics.

23. Study inhibition of POTW's by toxics. Priority will rise if ORD can demonstrate that question is amenable to effective research. (OWPS, Low)

24. Develop criteria for assessing BMP's used for toxics control. (OWE, High)

25. Develop information regarding POTW non-industrial toxics including potential sources, levels & control technologies. With the development of municipal pretreatment programs, we feel that mass balances will yield a substantial fraction of toxics from non-industrial sources. Research is also needed on the fate of organic solvents and other priority pollutants contained in marketed commercial subsurface system maintenance products along with the potential for groundwater contamination by these products. (Region I, High)

26. Develop predictive model for assessing toxicity, bioaccumulation and carcinogenicity of manufactured chemicals in POTW effluents and sludges. Specific manufactured chemicals would include priority pollutants and by-products other than the first 129 on the list. (Region V, High)

MUNICIPAL SLUDGE MANAGEMENT

1. Plant upgrading and design information for improved performance and reliability. (OWPO, High)

2. Design information on digestion processes with enhanced gas production. (OWPO, High)

3. Improved processes for energy recovery incineration including sludge dewatering work to reduce costs. (OWPO, High)

4. Evaluation of full-scale conversion systems (thermal, composting, vermiculture, etc.) (OWPO, Medium)

5. Economic study of co-disposal methodologies. (OWPO, Medium)

6. Air emission control equipment. (OWPO, OPTS, Medium)

7. Characterize existing sludge & septage disposal systems from a microbiological and toxics standpoint. (OWPO, Medium; OPTS, High)

8. Transfer available information on dewatering techniques. (OWPO, Medium)

9. BMP's for contaminated sludges, (OWPO, Medium)

10. Additional development and technology transfer of composting technologies (e.g., more economical bulking agents, within vessel systems, guide for small systems, etc.) (OWPO, Low)

11. Evaluate ash disposal & extraction for incineration. (OWPO, Low)

12. Fate & effect of toxics in sludges recycled to agricultural lands. (OWPO, Low)

13. Feasibility of metals extraction. (OWPO, Low)

14. Determine effect of pretreatment on sludge quality. (OWPS, OPTS, High)

15. Determine effects of metals and organics at various levels in sludge and assist in the development of criteria. (OWPS, High)

16. Assess lead in sludges as to chemical forms and availability. Major concerns are inhalation, ingestion and plant uptake routes. Integration of large, existing body of data necessary. (OSW, High)

17. Determine the health risks associated with the application of different levels of cadmium to land. Determine, for example, what a good Cd/Pb ratio might be. (OSW, high)

18. Evaluate the persistence of PCB's in sludge, their adherence to crop roots (ingestion by grazing), uptake by crops and retention (and concentration) in beef fat of grazing animals. Output needed to finalize RCRA/4004 regulation and CWAA/405 guidelines. Requested date: June, 1981. (OSW, High)

19. Risk assessment of other heavy metals and organics including exposure pathways. The assessment should utilize data from OWPS's 40-city survey and ORD's 25-city study. (OSW, High)

20. Determine the effectiveness of pathogen reduction processes. How effective are processes described in criteria? Assess the viability of parasites in sludge. (OSW, High)

21 Evaluate Cd-uptake by crops, especially tobacco, soy beans, peanuts, citrus fruits and other vegetables. (OSW, Medium)

22. Study non-food chain applications of sludge such as energy products and reclamation. Future effort - the influence of potential future uses of land upon application rates. (OSW, Medium)

23. Develop environmentally acceptable land-spreading and landfilling methods. (Regions I, VI, High)

24. Perform additional work on acceptability of "purifax" (BIF) system with respect to potential hazardous by-product formation. (Region I, High)

25. Evaluate high-energy electron irradiation of sludge. (Region I, High)

26. Provide assistance to the University of Connecticut in its study of the application of sludge to corn crops. (Region I, High)

27. Develop energy sources from sludge, largely the recapture of methane from sludge digestion). (Region I, Medium)

28. Investigate and evaluate new sludge disposal processes developed in Europe. (Region II, High)

28a. Promote the acceptability of landspreading and thermal destruction of urban area sludges. (Region II, High)

29. Extend land application information base to the monitoring of cadmium in sludge amended soil:

    o Develop monitoring techniques and appropriate procedures for PCB's and cadmium in sludge-amended land

    o Establish standard soil/plant tissue test for field monitoring of heavy metals, PCB's and organics

    o Develop state-of-the-art manual for techniques in monitoring cadmium, heavy metals and organics in sludge amended land. (Region V, High)

30. Develop acceptable practices for land application in western U.S. (Region VIII, High)

31. Develop pretreatment and disinfection criteria guidelines for wastes to be applied to land. (Region VIII, High)

32. Evaluate system trade-offs in the management of municipal and industrial sludge and other residuals. (Region IX, Medium)

PLANT OPERATION AND DESIGN

1. Design information for newer processes and high priority existing processes. (OWPO, Region I, High; Region IV, Medium)

2. Technical assistance in development of policy, guidelines, etc. (OWPO, High)

3. Assessment of toxics formation in POTW's due to processes such as superchlorination. (OWPS, High)

4. Methods to reduce energy consumption in POTW's. (Region I, High)

5. Methods to improve operational efficiency. (Region I, High)

6. Establish cost factors for municipal treatment alternatives. (Region III, High)

7. Develop refresher course for treatment plant operators. (Region IV, High)

8. Assess the reliability of sand, multi-media, or other types of final filters. (Region V, Medium)

9. Develop design parameters for optimum clarifier performance including:

    - Proper depth
    - Overflow rates
    - Weir rates (Region VIII, High)

10. Research in methodology to improve supernatant quality for anaerobic digestion of primary/secondary sludge (e.g., new Denver WWTP has problems in that it can't separate water from sludge properly). (Region VIII, High)

11. Demonstrate NH_4-N reduction treatment reliability in cold climate by various processes. (Region VIII, High)

LAND APPLICATION WASTEWATER AND AQUACULTURE

1. Update land treatment design manual. (OWPO, High)

2. Efficiency of preapplication treatment by lagoons, ponds, etc. (including verification of die-off rates of bacteria & virus in ponds used for preapplication treatment). (OWPO, High)

3. Extend overland flow design criteria (include determinations of the effect of rainfall dilution on bacteria & virus levels). (OWPO, High)

4. Design criteria and operating procedures necessary to insure protection of groundwater. (OWPO, High)

5.* Design/operating data for natural systems to meet different effluent qualities (include natural and created wetlands, macrophytes, etc.) (OWPO, High)

6. Site evaluation criteria for rapid infiltration design loads, (OWPO, Medium)

7. Evaluation of design & operational energy considerations (include bioconversion of harvested biomass, etc.) (OWPO, Medium)

8. Investigate long-term effects of land application. (OWPO, Low)

9. Management requirements for a range of slow-rate irrigation systems. (OWPO, Low)

10. Evaluate costs of aquaculture systems. (OWPO, Low)

11.* Evaluate ecological impacts of land treatment & aquaculture systems. (OWPO, Low)

12. Determine the impact of toxics on groundwater due to land application.

13. Determine fate of nitrate, sodium and heavy metals from land application. (Region I, High)

14. Study of lateral/vertical transport of pollutants. (Region I, High)

15. Develop methods to determine safe distances from water supplies for land application operations. (Region I, High)

16. Develop methods for sampling at aquifer interface. (Region I, High)

17. Develop design criteria for and determine the cost of evapotranspiration systems. (Region I, High)

18. Investigate (preferably under New Hampshire and Connecticut field conditions) nutrient retention in fast percolation lake soils. Recommend revised regulations as required. (Region I, Medium)

19.. Determine the effects of wastewater injection on groundwater quality. Goal is to determine if the groundwaters of Long Island are or could be contaminated by viruses, organics and/or heavy metals from percolation of groundwater or by the injection of treated wastewater. (Region II, Medium)

20. Develop design parameters for overland flow facilities in northern climates. (Region V, High)

21. Develop safe land application practices for Western states. (Region VIII, High)

22. Develop pretreatment and disinfection guidelines for wastes to be applied to the land. (Region VIII, High)

URBAN RUNOFF

1. Improve sewer rehabilitation & maintenance systems manual. (OWPO, High)

2. Support NEEDS SURVEY requirements. (OWPO, High)

3. Provide technical assistance team for sewer rehabilitation problems. (OWPO, Region I, Medium)

4. Develop CS technology for wet/dry weather flows. (OWPO, Low)

5. Develop a BMP selection and evaluation methodology. (OWPS, OWE, High)

6. Develop and evaluate multiple use projects. (OWPS, High)

7. Carry out study of toxicants in urban runoff to determine effect on biological integrity of receiving stream. (OWPS, OPTS, High)

8. Provide assistance in preparing urban runoff guidelines. (OWPS, High)

9. Generate data base to support development of wet weather flow criteria and standards. Research should identify impact on POTW's. (OWPS, Region V, High)

10. Assist in cooperative effort to quantify pollutant sources and impacts. (OWPS, OSW, OWE, High)

11. Evaluate urban runoff BMP's. (OWPS, Medium)

12. Determine the effectiveness of runoff control programs. (OWPS, Medium)

13. Provide technical support for control programs (CSO). (OWPS, Region I, Medium)

14. Carry out technology transfer. (OWPS, Medium)

15. Evaluate economic impact of BMP implementation. (OWPS, Medium)

16.* Determine the effect of urban runoff on water quality. (OWPS, Medium)

17. Conduct material balances for urban runoff (Sources, pollutants, chemical forms, discharges, etc.) (OWPS, Low; OPTS, Medium)

18. Carry out areawide evaluation of urban complex for problems and solutions. (OWPS, Low)

19. Perform analysis of stormwater data and develop tools for wet weather problems. (OWE, High)

20. Demonstrate sewer flushing on large sewers to define costs, design criteria and performance. (Region I, High)

21. Demonstrate microscreening with high rate disinfection for CSO control. (Region I, High)

22. Assess feasibility of using a single automatically-monitorable parameter to trigger activation of CSO facility in an effort to capture (treat) only the "heart" of CSO surge. Possible suggestions include oxidation-reduction potential, light transmission, chlorine demand. Goal is attempt to optimize size and operation of CSO facility. (Region I, High)

23. Determine the feasibility of co-disposal. (Region II, High)

24. Determine both short-and long-term impact of runoff on receiving waters. (Region II, Medium)

25. Assist in formulation of water quality criteria for stormwaters particularly with respect to nutrients, sediments and toxics. (Regions IV, VII, High)

CONSERVATION AND REUSE

1. Develop non-potable reuse criteria. (OWPO, Medium)

2. Determine feasibility of potable reuse. (OWPO, Low)

3. Identify important conservation elements and pricing approaches. (OWPO, Low; Region I, High)

4. Develop analytical protocols for reuse. (OWPO, Low)

5. Evaluate energy savings of conservation. (OWPO, Low)

6.+ Develop systems approach to minimize environmental damage to biota from use of cooling water for industry. (Region II, Low)

7. Technical and economic assessment of proper means to implement water conservation and reclamation/reuse measures based on sound R&D data. (Region IX, High)

8. Feasibility study of using saltwater for toilet flushing and ground water protection. (Region IX, Low)

SMALL WASTEWATER FLOWS

1. Continue assessment of existing and new technologies (include land treatment and aquaculture techniques). (OWPO, Region II, High)

2. Manual of practice on septage. (OWPO, High)

3. Develop design and operating procedures to protect groundwater. (OWPO, High)

4. Improve design performance & reliability of available technologies (including rejuvenation techniques for failing systems). (OWPO, Medium)

5. Technology transfer function (include protocol for better institutional arrangements). (OWPO, Medium)

6. Evaluate cost-effectiveness (cost & water conservation). (OWPO, Medium)

7. Identify needs for the home of 2001. (OWPO, Low)

7a. Perform a screening study for toxicants in individual home treatment systems. (OPTS, High)

8. Information on best practicable technology for the treatment and disposal of septage. (Region I, High)

9. Methods to reliably predict life expectancy of septic tank leaching fields. Additional research is necessary to determine leaching field application rates based on soils, system size and system design. Specific guidance for soil sampling and soil evaluation in leaching field design is also required. (Region I, High)

10. Septage treatment technologies suitable for suburban (as opposed to rural) areas in New England climate. (Region I, High)

11. Methods to handle sidestream from acid-lime stabilization "pretreatment" of septage. (Region I, High)

12.* Determine effects of SWF's on wetland water quality. (Region IV, Medium)

13. BMP for non-point source control will eventually become required practice. Cost effectiveness and specific benefit of each BMP need to be determined. (Region V, HIgh)

14. Investigate dual septic tank impact, in series, on pathogen dieoff, decrease of solids removal, and increase of absorption field longevity. (Region V, Medium)

15.* Assist in developing criteria for ecologically sound use of wetlands. Research is to focus on questions concerning productivity and reasonable alternatives. (Region VI, Medium)

INNOVATIVE AND ALTERNATIVE TECHNOLOGY

1. Continuation of Technology Support Group for Construction Grants Program. (OWPO, High)

2. Provide additional effort (2 man yr minimum) for Administrator's initiative in innovative wastewater treatment/energy technologies. (OWPO, High)

3. Monitor I/A Program for technology research opportunities. (OWPO, Medium)

4. Perform detailed evaluation of selected projects (105j). (OWPO, Medium; Region V, High)

5. Evaluate performance of I&A technologies relative to toxics removal (toxicant concentration and effects). (OWPS, High)

6. Establish formalized procedure/methodology for post-construction verification of energy savings criteria, including special criterion that has been designated for anaerobic digestion, i.e., 90% fuel reuse. (Regions I, VIII, High)

7. Establish formalized criteria for determining justification for 100% replacement cases. (Region I, High)

8. Provide support for I&A clearinghouse. (Region I, High)

9. Demonstrate vertical tube reactor system. (Region VIII, High)

10. Demonstrate wet oxidation of sludges. (Region VIII, High)

HEALTH EFFECTS

Toxic Pollutants Control (TC)

TC-1 Health effects of reused water for irrigation and sludge applications to agricultural and domestic lands. (Region VIII, High)

Municipal Sludge Management (SM)

SM-1 Perform state-of-the-art health assessment on sludge. (OWPO, High)

SM-2 Provide technical assistance in pediatric study of lead exposure on effects of sources of lead; how much risk is involved? (statistical analysis, coordination needed). (OSW, High)

SM-3 Perform assessment of PCB's in dairy products and beef fat. Determine the relationship between sludge PCB content and resulting concentrations in milk and beef fat of cattle grazing on crops grown on sludge-amended soils. (OSW, High)

SM-4 Assess the health effects of other metals (beyond lead and cadmium and organics. (OSW, High)

SM-5 Develop acceptable landfilling and landspreading methods. (Region I, II, High)

SM-6 Evaluate new European technology. (Region II, High)

SM-7 Determine the impact of land application of sludge on groundwater. (Region IV, High)

SM-8 Determine the fate of viruses and pathogens in land application. (Region VII, High)

SM-9 Information on possible health effects caused by consumption of foodstuffs grown in soils supplemented with wastewater sludges. (Region IX, High)

Land Application of Wastewater and Aquaculture (LA).

LA-1 Perform a state-of-the-art health assessment. (OWPO, High)

LA-2 Carry out detailed health effects assessment. (Region I, High)

LA-3 Develop research data on the potential health impact on groundwater from land application of wastewater sludges. (Region IV, High)

LA-4 Final guidelines based on the effects of pathogens in soils and aerosols from wastewater treatment process (spray irrigation). (Region IV, High)

LA-5 Establish infective (clinical) dose/response data on aerosols in land application. (Region V, High)

LA-6 Determine need for disinfection prior to wastewater application. (Region V, High)

LA-7 Determine fate of virus and bacteria in aquaculture and wetlands systems. (Region V, High)

LA-8 Information on viral contamination and carcinogenicity when wastewater is applied to land. (Region VI, High)

LA-9 Develop simplified procedures/methods for identification and removal of viruses. (Region VI, High)

LA-10 Information on spray irrigation (transport of viruses). (Region VI, Medium)

LA-11 Develop information on potential health effects resulting from consumption of foodstuffs grown in soils irrigated by wastewater. (Region IX, High)

Conservation and Reuse (CR)

CR-1 Develop information on water reuse and conservation techniques. (Region VIII, High)

CR-2 Effects of percolation of municipal effluents into potable groundwater aquifer. (Region IX, High)

Small Wastewater Flows (SWF)

SF-1 Determine health impact of SWF systems. (OWPO, Medium)

SF-2 Assess health/environmental effects of various small wastewater treatment systems (aquaculture, pressure sewers, septic tanks, composting toilets). (Region IX, Medium)

GENERAL RESEARCH REQUIREMENTS

1. Provide technical support in instrumentation on demand.
2. Develop improved flow measurement methods. (OWE, Medium)
3. Develop remote sensing methodologies (discharges, collection systems, impacts, etc.). (OWE, Medium)

* Interface with Waster Quality Committee

+ Interface with Industrial Wastewater Committee

ADDITIONAL DETAIL ON OWPO RESEARCH REQUIREMENTS

OWPO Research Needs Concerning Municipal Wastewater Treatment and Sludge Management As Inputs Into the Five Year ORD Research Strategy Plan

Alan B. Hais, Chief
Municipal Technology Branch (WH-547)

August 29, 1979

William A. Rosenkranz, Director
Waste Management Division (RD-682)

OWPO has developed a listing of research needs that we feel should receive priority consideration during the development of the five-year ORD research strategy plan on municipal wastewater treatment and sludge management. For the most part these research needs have been directed towards answering specific project design, management and operations questions. In addition, some of the needs are aimed at the development of new or refinement of existing technologies.

RKBastian;lss;8/21/79

"CONVENTIONAL" WASTEWATER TREATMENT TECHNOLOGY

1. Design Information & Guidelines

   o need to continue updating existing design information and guidelines

   o need to develop design information and guidelines for newer processes and improvements not previously covered

   o in an effort to develop design guidelines, EPA may want to arrange for "peer review" of initial drafts developed by the Agency and to encourage eventual adoption of the final guidelines by professional societies

   o preferably, EPA may want to stimulate professional societies to undertake the comprehensive effort of developing updated design guidelines (possibly EPA would want to provide "seed" money to help initiate such efforts by professional societies)

2. Energy Considerations

   o need to concentrate research efforts on those phases of treatment systems where energy consumption is the greatest (e.g., aeration, pumping, thermal drying or reduction in sludge volumes, sludge conveyance, etc.)

   o need to emphasize areas where energy conservation or recovery is directly related to treatment process; secondary attention should be given to "non-treatment" components (e.g., "substitutes" or alternatives to energy intensive consumables used in treatment processes such as lime, chlorine and alternative disinfectants vs outfall turbines and heat pumps)

3. Toxics Considerations

   o need to develop practical and feasible in-plant treatment processes for toxics removal at the municipal treatment plant

   o essential considerations relative to "practicality" and "feasibility" of such processes center on:

     - cost (absolute costs and cost/benefit aspects)
     - energy requirements
     - eventual fate of toxics (i.e., are toxics just transferred to sludge)

   o need to address "binding" of toxics by fixation or extraction of toxics from sludge - with some attention to feasibility of recovering potentially reusable metals

4. Disinfection Considerations

- need to continue work on alternative disinfectants (e.g., those already identified as well as work on possible new alternatives)

- areas of concentration are:

  - cost
  - energy (see "energy" section)
  - improved effectiveness of "conventional" effluents (as opposed to "AWT-quality" effluents)

5. Miscellaneous Considerations

- in view of the recent funding decision within ORD concerning technology transfer, a certain portion of the actual research and development budget must be set aside to support information dissemination of successful research results

- need to develop and undertake improved influent characterization and treatability estimation techniques

- need to develop and undertake improved rehabilitation and sewer maintenance systems (infiltration/inflow correction)

- although it may at first appear to move us too far into providing direct technical assistance, we should explore the possibilities of establishing a group of experienced in-house technical experts to help treatment plant operators deal with major operational problems - many of which have been linked to design deficiencies and to a lack of qualified technical experts to provide guidance on what corrective measures need to be taken. A group of EPA "experts" to provide this type of technical assistance would be far more valuable than an endless list of technical reports and studies that few may take time to read.

"LAND TREATMENT" AND OTHER INNOVATIVE/ALTERNATIVE TECHNOLOGIES

1. Land Treatment & Related Technologies

- need to emphasize efforts aimed at providing necessary data to update the Land Treatment Design Manual including:

  - studies on long term effects of slow rate, rapid infiltration and overland flow treatment technologies

  - detailed studies on design/performance of newer systems (especially overland flow systems applying raw wastewater)

  - detailed monitoring and evaluation of design/performance information from various natural systems (e.g., wetlands, water hyacinths, polyculture systems)

- o need to complete state-of-the-art health assessment report on land treatment of municipal wastewater and address issues not resolved by the assessment report

- o need to undertake special studies to address the following:

  - microbiological evaluation of runoff from slow rate land treatment systems

  - verification of die-off rates for fecal coliforms and virus in ponds (especially as used for preapplication treatment for land treatment systems)

  - determining the dilution/reduction effects of fecal coliforms resulting after rainfall on overland flow land treatment systems (especially where raw wastewater is applied at the top of the slope)

  - defining microbiological impact on reuse potentials of water recovered from land treatment systems (i.e., underdrains, etc.)

  - addressing whether there are microbiological or other health risks due to translocation of pathogens, toxics, etc. if dairy or other animals graze on land treatment sites

  - defining health impacts if micro-organisms content of runoff, etc. is due to domestic and wild animals on the sites and not original sewage sources and then developing a simple technique for identification of sources

  - undertake additional studies to evaluate potential ecological impacts of land treatment and other natural systems, with emphasis upon feeding wildlife and biota produced on the treatment sites

2. Onsite Systems

- o the present onsite systems research program appears very responsive to OWPO needs and should be continued, placing emphasis upon improving design, performance, management, and reliability of onsite systems

3. I/A Program

- o need to undertake detailed evaluations of selected innovative and alternative systems constructed through the I/A program (this would be in response to Sec. 105(j) of CWA plus independent ORD initiatives as funding allows)

- o need to be in constant contact with actual operation of I/A program and then key a portion of future research efforts off of promising technologies which offer significant potential but have not been sufficiently developed for full-scale implementation under the I/A construction grants program

SLUDGE & SEPTAGE MANAGEMENT PRACTICES

1. Processing and Treatment

   - need to generate more upgrading, design, and operations oriented information to help improve existing facilities' performance and reliability while decreasing O&M problems and costs, such as:

     - thickening information on handling both gravity and air flotation upsets, summer *vs* winter performance, etc.

     - dewatering information on the use of conditioning chemicals and operational problems (and their management) associated with newer dewatering equipment (e.g., presses, filter belts, etc.), including the design of chemical feed systems, use of automatic and mechanical feed control systems, amount and type of operator training needed, etc.

     - digestion information on design and operating procedures to minimize cleaning to control buildup of grit and scum; information on enhancing gas production by such means as chemical additives

2. Conversion Processes

   - need to place more emphasis upon making toxic heavy metals in sludge more unavailable for plant uptake rather than continuing any major efforts to explore expensive extraction methodologies relative to municipal sludges - unless the industrial R&D programs desire to pick up such work as potential source of raw materials

   - need to place more emphasis upon the development of more reliable and more efficient air emission control equipment (including lower costs and energy efficiency) to allow thermal technologies to be implemented in areas with major air quality problems; should include evaluations of emission control systems for co-disposal and pyrolysis systems

   - need a good economic study of co-disposal methodologies to help identify the best available techniques, including costs of converting existing incinerators to handle sludge (e.g., solid waste incinerators, coal fire power plant boilers, etc.)

   - need efforts to help identify best available technologies for recovery of energy from thermal processing equipment, including retrofitting of existing facilities and best designs for new facilities

   - need detailed evaluations of full-scale conversion systems such as incineration with energy recovery, pyrolysis, co-disposal, composting

   - need an easy-to-follow composting guide to assist new facility design, start-up and operation (especially for small sized systems)

- need to identify more economical bulking agents for composting systems which require them and to provide more information on within-vessel composting equipment

3. Disposal/Utilization Practices

- need to complete the state-of-the-art health assessment report on land application of municipal sludge
- need to provide more definitive information of fate and effects of toxic organics in sludges, especially when recycled on agricultural lands
- need to give more attention to good management practices for "contaminated" sludges, including possible beneficial uses for non-agricultural purposes (e.g., reclamation of drastically disturbed lands that would be dedicated for non-agricultural purposes, etc.) as well as improved design and management of disposal practices (e.g., high rate surface application to dedicated sites, landfills, etc.)
- need to undertake special studies to address the following if they are not adequately addressed in the state-of-the-art health assessment report:
    - characterize existing sludge and septage land application systems from a microbiological and toxics standpoint (emphasizing actual levels in soil, runoff, groundwater, and crops grown on cropland and other areas receiving liquid or dewatered, composted, etc., sludges that have received various levels of stabilization - including no stabilization)
    - addressing whether there are microbiological or other health risks due to translocation of pathogens, toxics, etc., if dairy or other animals graze on land treatment sites
    - defining health impacts if micro-organisms content of runoff, etc. is due to domestic and wild animals on sites and not original sludge sources and then developing a simple technique for identification of sources
    - undertake additional studies to evaluate potential ecological impacts of land application systems, with emphasis upon feeding wildlife and biota produced on the treatment sites

APPENDIX C

LISTING OF RESEARCH OUTPUTS BY RESEARCH CATEGORY

I. LISTING OF RESEARCH CATEGORY 1 OUTPUTS BY MAJOR R&D AREA

Research Area	Research Output and Date (Priority)
1. WASTEWATER PROCESS DEVELOPMENT	
New Biological Process Development	
Upgraded Lagoon Treatment by Simple Low Cost Methods	Lagoon upgrading design manual (M) (Output by 3/81)
Efficient O_2 Transfer to Biological Systems	Standard/procedural manual for conducting and evaluating O_2 transfer test (H) (Output by 10/80)
Application of RBCs to Municipal Wastewater	Survey to develop interim RBC design guidelines (H) (Output by 6/80)
Biodegradation and Specific Pollutant	
Biodegradation Studies of Priority Pollutants (PP)	Interim report on biodegradation protocol for selected PP (H) (Output by 3/80)
2. TOXIC POLLUTANTS CONTROL	
Toxics Data Base: Generation, Management, and Indicator Development	Interim reports on toxics at POTWs (survey), analysis of influents, effluents, and sludges (H) (Output by 12/80) Compendium and assessment report (H) (Output by 7/81)
Toxics Removal Process Evaluation and Development	T and E facility toxics work (Output by 10/80, 10/81)
Toxics Treatability	Biodegradability of priority pollutants (H) (Output by 10/83)

3. MUNICIPAL SLUDGE MANAGEMENT

Processing and Stabilization

Disinfection and Stabilization	Purifax evaluation report (H) (Output by 12/79)

Conversion and Energy Recovery

Evaluate Thermal Processes and Energy Recovery	Evaluation of coinincineration project (H) (Output by 12/79)
Characterize Emission from Sludge Disposal Facilities	Reports on sludge incinerator emissions (H) (Output by 10/79)
Evaluate Composting and Other Processes	Additional Evaluations (H) (Output by 10/80)

Land Application Management and Disposal

Assess Fate and Effects of Pathogenic Organisms	Pathogen requirements for RCRA (H) (Output by 8/80)

4. INNOVATIVE AND ALTERNATIVE TECHNOLOGY

I and A Technology Program Support	Revised interim I and A technology assessment manual (H) (Output by 10/79)
	Annual management effectiveness reports (H) (Output by 6/79, 6/80, 6/81)
	Clearinghouse report (H) (Output by 10/80)

II. LISTING OF RESEARCH CATEGORY 2 OUTPUTS BY MAJOR R&D AREA

Research Area	Research Output and Date (Priority)
1. WASTEWATER PROCESS DEVELOPMENT	
New Biological Process Development	
Efficient O_2 Transfer to Biological Systems	Evaluation of large-scale deep shaft activated sludge system (H)
	Dirty water evaluation of new, high-efficiency submerged air aeration equipment (H)
Application of RBCs to Municipal Wastewater	Field study to develop RBC design criteria (M)
Evaluation of Batch Reactors and Fluidized Bed Reactors	Full-scale evaluation of fluidized bed reactor on carbonaceous material (H)
Biodegradation and Specific Pollutant Removal	
Biodegradation studies of Priority Pollutants (PP)	Lab Study of Static Biodegradation of PP (H)
	In-house continous flow studies of PP (M)
Nutrient Removal	Design manuals on nitrogen (N) and phosphorous (P) removal (M)
	Analysis of P removal in Great Lakes (M)
Microbiological Control	
Chlorination and Dechlorination	Report on optimization of chlorination process (H)
Ultraviolet Light (UV)	Full-scale demo of 1st generation UV light disinfection of wastewater (H)

Disinfection SOA Technology Transfer	Report on risk-benefit-cost of alternate disinfection (M) Disinfection evaluation manual (M)

2. TOXIC POLLUTANTS CONTROL

Toxics Data Base: Generation, Management, and Indicator Development	Data generation by city survey (H) Correlations of toxics removal with simple parameters (H) Test of Alternative indicator approaches (H) Computerized cost optimization model for urban toxic control strategies (M) Risk assessment model for meeting regulations under various control strategies (M)
Toxics Removal Process Evaluation and Developments	Toxics stripping from aeration basin (measurement and modeling) (H) Improved analytical techniques for organics extraction from wastewater and sludges (M) Improved clean-up techniques for increased sensitivity and precision (M)
Toxics Treatability	Progress reports on biodegradation lit survey, carbon adsorption structure-activity analysis and organics stripping model (M)

3. MUNICIPAL SLUDGE MANAGEMENT

Processing and Stabilization

Dewatering and Conditioning	Technology assessment for dewatering to high-cake solids (H)

Disinfection and Stabilization	SOA report on Vermicomposting (M)
	Report on pathogen survival in aerobic digestion (M)
	Report on gamma ray irradiation for stabilization (M)
	Evaluation of new and innovative methods (M)
	Procedure for characterizing sludge stability (H)
Energy-Related Sludge Technology	Solar energy and digester gas use demo (M)
	OTAM digestion demo (M)
	SOA report on costs and benefits (M)
	Report on improved anaerobic digester and energy production (M)
Toxicants Removal	Report on heat and acid treatment for conditioning heavy metals removals (M)
	Assessment of present technologies for heavy metals removal (M)
Conversion and Energy Recovery	
Evaluate Thermal Processes and Energy Recovery	Evaluation of 2nd coincineration process (with OSW) (M)
	Evaluation of pyrolysis with RDF addition and high solids cake (L)
Characterize Emissions from Sludge Disposal Facilities	Evaluation of incinerators with best SOA pollution control devices (H)
	Study of advanced technology for controlling emissions from thermal conversion processes (M)
	Summary report on incinerator emissions and evaluation of advanced control technologies (M)

Evaluate Composting and Other Conversion Processes	Report on European technology and leading within-vessel process (M)
	Demo of unique U.S. composting process (M)

Land Application Management and Disposal

Impacts of Toxicants on Crop Response and Site Life	Effects of long-term use (H)
	Chemistry of metals in sludge-ammended soils (M)
	Soil factors affecting metal absorption (M)
	Cumulative loadings of metals vs annual sludge application (H)
	Impacts of prolonged application at various rates (M)
	Crop uptake of metals under various soil properties (M)
	Crop response to various application rates and soil types of Eastern U.S. (M)
	Effects on selected crops on long-term sludge use under various management schemes (M)
	Approved methods for sampling and analysis (H)
	Report on toxics in sludge (M)
	Fate and effects of toxic organics in sludge applied to agricultural land (M)
Sludge Management Practices for Soil Systems	Proper site management on agricultural soils (M)
	Demo of best available technology for using sludge as fertilizer on farms (M)
	Effects of long-term sludge application (H)

	Fate/effects of nutrients under various methods for Eastern U.S. soils (M)
	Demo of sludge use to reclaim acidic mine spoils (H)
	Effects of accumulation of sludge from several years of application (H)
	Fate/effects from various land application management schemes (M)
Assess Fate and Effects of Pathogenic Organisms	Static pile composting (M)
	Parasites in sludge (M)
	Helminth transmission from sludge use (M)
	Demo of beneficial use of sludge on farms (M)
	Effectiveness of sludge storage in diminishing parasitic ova (M)
Assess the Use of Sludge for Energy and Other Non-Food Chain Crops	Non-food chain crops from sludge (M)
Assess Long-Term Impact of High Rate Application on Soil	Use of Sludge to reclaim acid mine spoils (H)
	Management document for sludge use in mine reclamation (M)

4. PLANT OPERATION AND DESIGN

Analysis of Operational and Design Factors Affecting Performance	National O&M cause and effect survey (M)
	Protocol for comprehensive plant evaluations (M)
	Analysis of effectiveness of wastewater collection systems (M)
	Land application/alternative technology guidelines (H)
	Design Guidelines for Conventional systems (H)

Remedial Methodology Development	Composite correction program for improving POTW performance (H)
	Demo of automation and in-process control strategies (M)
	Centralized management strategies for small plants (M)

5. LAND APPLICATION OF WASTEWATER AND AQUACULTURE

Land Application of Wastewater

Land Treatment Task Force	Task force report (H)
Assessment of long-Term Effects from Six Slow-Rate Systems	Summary report on existing slow rate systems (M)
Lubbock Demonstration of Slow-Rate Irrigation	Construction complete (H)
	Research Reports (H)
	SOA report on slow-rate land treatment (H)
Assessment of Long-Term Effects From Four Rapid Infiltration Systems	Summary report on existing rapid infiltration systems (M)
Develop Design and Operating Criteria for Overs	Interim Criteria report (H)
	Final criteria including Northern climates (M)
Develop Design and Opertion Criteria for Rapid Infiltration Systems	Revised design criteria (M)
	Design criteria for environmentally controlled systems (L)
Evaluate Design and Opeartion of Slow-Rate Systems	Revised design and operating criteria (M)
Soil Transport and Transformation of Toxic Substances	Series of reports on toxic substances interaction with soils (M)
	Predictive models (L)
Case Studies of Land Treatment Systems	Reports on 10 systems (H)

Aquaculture and Wetlands

Evaluate Effectiveness of Water Hyacinths for Treating 1^o and 2^o Effluent	Preliminary design criteria for water hyacinth treatment (H)
	Evaluation of environmental control units (M)
	Evaluation of hyacinth harvesting and utilization (M)
Evaluate Artificial and Natural Wetlands For Treatment and Disposal	Annual interim reports (M)
	Assessment of wetlands for municipal wastewater (M)
Technology Transfer	Numerous technical support activities (M)

6. URBAN RUNOFF

Pollution Problem Assessment	Matrices of causes and effects of urban runoff (short-term) (M)
	Longer term impact matrices (M)
	Nationwide assessment of receiving water impacts (M)
	Assessment of toxic and carcinogenic potential of urban runoff and CSOs (M)
	Impact of wet weather flows on DO levels (M)
	Studies of sediment impacts and benthic effects (multi-city) (M)
	Movement and effects of CSO sediments in receiving waters (M)
Stormwater Pollution Control	Compendium of urban wetland utilization (L)
	Compendium of BMPs for urban runoff pollution control (L)

		Document on remedial considerations in urban runoff pollution abatement (L)
		Needs survey support (M)
		Section 208 (NURP) support (H)
		Demo of eutrophic lake restoration (M)
	CSO Pollution Management	Assessment of dual (wet/dry weather facilities (M)
		Planning and design principles for urban runoff control facilities (M)
		I/I control technology (H)
		Great Lakes Program cooperative projects (M)
7.	MUNICIPAL WASTEWATER REUSE AND CONSERVATION	
	Denver Potable Water Reuse Demonstration	Completed design (M)
		Construction complete (M)
		Trial operation completed (M)
	Potable Reuse Demonstration at Existing Sites	Final reports on facilities having different geographic, climatic, and institutional characteristics and treatment processes (M)
	Water Conservation Practices Impact on Wastewater Collection and Treatment Systems	California report (M)
	Non-Potable Reuse Criteria and System Evaluations	Reuse guidelines (M)
		System evaluation reports (M)
		Water quality criteria report (M)

8. SMALL WASTEWATER FLOWS

Systems Management for Small Communities	Describe the design, operation/maintenance, costs and applicability for septage handling, treatment, and disposal options (H)
	Characterization of existing water quality management districts (H)
	Reports on "piggyback" demo projects (H)
	Manual on optimum community-wide management strategies (H)
	Handbook on optimized systems for small communities (H)
	Interim report on pumpout treatment (H)
	Handbook of design, O&M, cost, and applicability data (Output by 6/85) (H)
Alternative Technology for Small Systems	Interim report on alternative on-site systems (H)
	Public health and environmental implications (H)
	Comprehensive manual on most promising systems and cost-effective remedial measures (H)

9. INNOVATIVE AND ALTERNATIVE TECHNOLOGY

I & A Program Support	Studies of effectiveness in meeting National goals (H)
	I & A program and trend reports (H)
Energy Use in Wastewater Treatment Facilities	Energy conservation in reuse, recycle and conservation (H)
	Energy assessment procedures manual (H)
	Report on energy effectiveness-wastewater and residuals (H)

10. HEALTH EFFECTS

Land Application of Sludge and Treated Wastewater	Appraisal of irrigation of agricultural land using treated wastewater (M)
	Assessment of health aspects of land application systems (H)
	Appraisal of fate of viruses in groundwater recharge system (H)
	Technology for microbial measurements of aerosols (M)
	Appraisal of animal viruses in soil/water systems (M)
	Pathogen hazard to farm families (M)
	Appraisal of processing and land application of municipal sludge (M)
	Occurrence, cross-transmission and infectivity of parasites in sludge (M)
	Levels of cadmium exposure indicators in U.S. (M)
	Sludge effects via animal pathways (M)
Health Effects Associated with Domestic Water Reuse	Rapid toxicity testing procedures using mammalian cells (M)
	Data base on virus spectrum in AWT plants (M)
	Mutagenic/carcinogenic potential of organic substances in renovated waters (M)
	Criteria for use of renovated wastewater for potable purposes (H)
	Aquaculture (M)

	Evaluation of organics in wastewater processed for reuse (M)
Appraisal of Health Effects of Other Sludge Treatment, Disposal, and Utilization Practices	Composting processes (H)
	Assessment of health aspects of land application systems (H)
	Epidemiological studies near sludge incineration and drying processes (M)
Urban Runoff and Wastewater Treatment	Improved indicators of treatment efficiency and/or potential health effects (M)
	Epidemiological studies relating to treatment (M)
	Develop microbial treatment criteria for stormwaters (M)

III. LISTING OF RESEARCH CATEGORY 3 OUTPUTS BY MAJOR R&D AREA

Research Area	Research Output And Date (Priority)
1. WASTEWATER PROCESS DEVELOPMENT	
New Biological Process Development	
Upgraded Lagoon Treatment by Simple Low-Cost Methods	Reports on algae removal using slow rock and intermediate sand filters (M)
Efficient O_2 Transfer to Biological Systems	Evaluation of full-scale activated biofiltration system (M)
	European survey of fine bubble diffusers (M)
	Clean water evaluation of submerged air aeration equipment (M)
	Large-scale evaluation of reactor/clarifier activated sludge process (L)
Application of RBCs to Municipal Wastewater	National symposium on RBCs (Proceeding) (M)
Evaluation of Batch Reactors and Fluidized Bed Reactors	Full-scale study of sequencing batch reactors (L)
Biodegradation and Specific Pollutant Removal	
Nutrient Removal	Evaluation of Barden PHO process (M)
	International nutrient control seminar (L)
	Feasibility study of low cost low residual P removal process (L)
	Field evaluation of above process (L)

Microbiological Control

Ozonation	Report on techniques for ozone measurement (L)
	Full-scale demo of ozone disinfection of wastewater (M)
	Evaluation of ozone for disinfection and trace toxic organics control (M)
Ultraviolet Light (UV)	Evaluation of UV for disinfection and trace organic control (M)
Chlorine Dioxide (ClO_2)	Comparison of ClO_2 to chlorine for use (L)
Disinfection of Antibiotic-Resistant Organisms	Report on occurrence of antibiotic-resistant coliforms (M)
	Effectiveness of disinfection upon resistant organisms (L)

2. TOXIC POLLUTANTS CONTROL

Toxics Removal Process Development and Evaluation	Additional studies on full-scale plants (M)
	Cadmium and metals removal by lime precipitation (M)
	Biological treatment modification by adding adsorbents (M)
	Biological modification studies (L)
	Additional improvements and new procedures from other projects (L)
	Evaluation of ozone/carbon absorption toxics removal (M)
Toxics Treatability	Carbon absorption treatability and modeling (M)

3. MUNICIPAL SLUDGE MANAGEMENT

Processing and Stabilization

Dewatering and Conditioning	Yearly report on cost, performance and design data on thickening and dewatering (M)
	Data on top-feed rotary vaccum filter (L)
	Full-scale evaluation of dewatering devices (M)
	On-site studies in thickening and dewatering (L)
	SOA report on chemical sludge handling (M)
	Evaluation of devices for producing high-solids cake (M)
Disinfection and Stabilization	SOA report on lime stabilization (H)
	Report on detoxification by aerobic thermophilic digestion (M)
	Solids separation without 2nd stage digestion (L)
Energy-Related Sludge Technology	Report on improved anaerobic digester and energy production (M)
	Demo of modular gas turbine for POTW energy (M)
Toxicants Removal	Pilot-scale test of heavy metals process (L)
	Heavy metals removal by centrifugal classification (L)

Conversion and Energy Recovery

Evaluate Composting and Other Conversion Processes	Report on composting on a barge (L)

Study Emerging Resource Recovery Processes	Evaluation of wet oxidation in a deep-well reactor (M)
	Contractor evaluation of deep-well wet oxidation (M)
	Feasibility study of liquefaction of sludge to produce synthetic asphalt (M)
	Evaluate operation of asphalt plant (L)
Land Application, Management, and Disposal	
Impacts of Toxicants on Crop Response and Site Life	Sludge utilization on sandy coastal plains (M)
Sludge Management Practics for Soil Systems	Nutrient transformations in sludge-amended soils (M)
Assess Fate and Effects of Pathogenic Organisms	Fate of viruses in sludge treated soil (M)
Assess the Use of Sludge for Energy & Other Non-Food Chain Crops	Sludge use in a Western forest (L)
	Feasibility of energy crop production with sludge (M)
	Sludge use to grow trees in Eastern U.S. (M)
	Use of sludge to produce turf grass (M)
Assess Long-Term Impact of High Rate Application on Soil	Comparison of infrequent large application with numerous smaller ones (M)
	Evaluation of sludge landfilling (L)
	Assessment of high rate application (M)

4. PLANT DESIGN AND OPERATION

Analysis of Operational and Design Factors Affecting Performance	Computerized performance and O&M data base (M)

Remedial Methodology Development	Process control strategies for wastewater and residuals (M)
5. LAND APPLICATION OF WASTEWATER AND AQUACULTURE	
Land Application of Wastewater	
Develop Mathematical Model for Determining Kinetics and Reactions of P in Soils	Report on model (M)
Nitrogen Management Model	Interim reports (L) Final model for N-management in soil treatment (M)
Aquaculture and Wetlands	
Evaluate the Use of Fish Species in Wastewater Treatment	Assessment report for indigenous and exotic fish species (M)
6. URBAN RUNOFF	
Pollution Problem Assessment	Symposium on receiving water impacts from urban stormwater (M)
Stormwater Pollution Control	Demo of swirl, helical bend and teacup concentrator/regulators (M)
CSO Pollution Management	Storage/sedimentation design manual (M) Stormwater evaluation methodology and flow monitoring manual (M) Sedimentation/ASP/CS project report (M) Demo of high gradient magnetic separation (L) Demo of dual use treatment of RBCs (L) Demo of fluidized bed reactors (L)

7. MUNICIPAL WASTEWATER REUSE AND CONSERVATION

Water Conservation Practices Impact on Wastewater Collection and Treatment Systems	East and Midwest reports (L)
	Guidelines (L)
Non-Potable Reuse Criteria and System Evaluations	Dual distribution users manual (L)

8. SMALL WASTEWATER FLOWS

Systems Management for Small Communities	Interim report on septic tank effluent implications for pressure and vacuum sewer systems (M)
	Comprehensive manual synthesizing data on applicability, design, O&M, and costs of pressure and vacuum sewer systems (M)
	Interim reports on integrated systems and components (M)
	Report on seasonal home systems (L)
	Interim reports on most promising techniques for wastewater treatment disposal and recycle for problem sources (L)
	Handbook summarizing data on techniques (L)
Alternative Technology for Small Systems	Baseline report on wastewater generation, building technology, energy systems and other utility systems (M)
	Report on ways to integrate home systems to conserve energy and water and to reuse water (M)

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